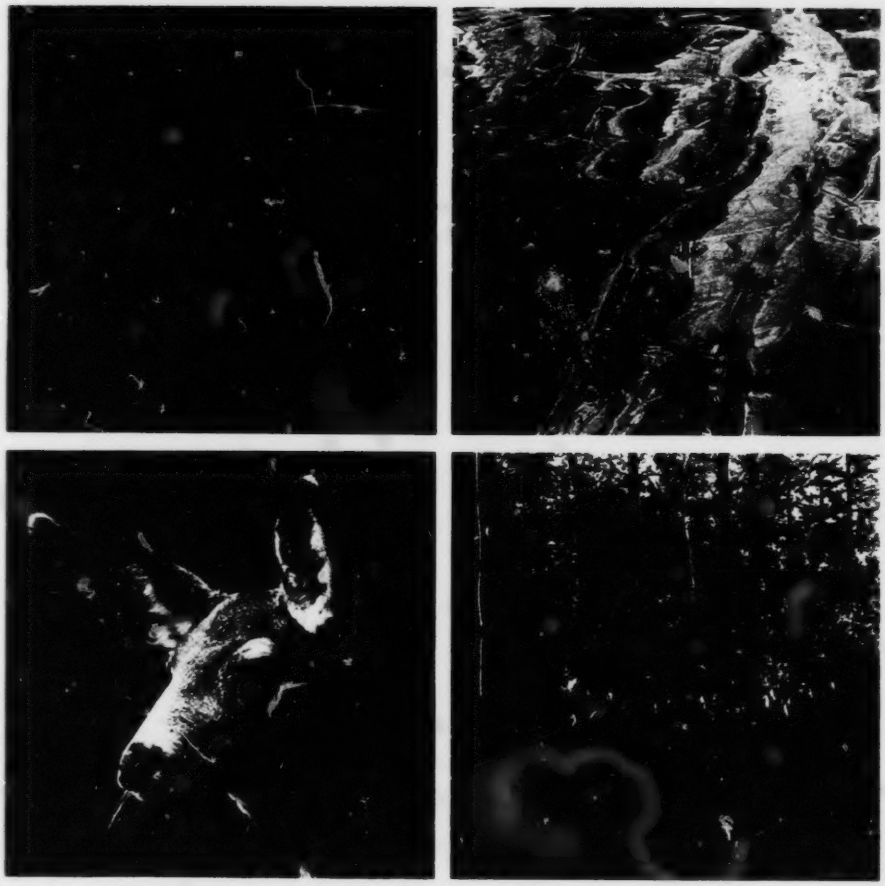
Jeffrey E. Green,
Richard E. Salter
and
Courtland E. Fooks



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Reclamation of Wildlife Habitat in the Canadian Prairie Provinces

Volume I:

Techniques for the Creation and Enhancement of Wildlife Habitat

87-05083/

RECLAMATION OF WILDLIFE HABITAT IN THE CANADIAN PRAIRIE PROVINCES
VOLUME I:
TECHNIQUES FOR THE CREATION AND ENHANCEMENT OF WILDLIFE HABITAT

by

Jeffrey E. Green,
Richard E. Salter
and
Courtland E. Fooks

The Delta Environmental Management Group Ltd.
Calgary, Alberta

for

Canadian Wildlife Service,
Environmental Protection Service,
and
Recreation, Parks and Wildlife Foundation.

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PREFACE

The following two volume report represents the first phase of a two-part study on reclamation of wildlife habitat in the prairie provinces of Canada. The report consists of a synthesis of existing technical information on approaches to and methods for reclamation of wildlife habitat (Volume I), and a review of the habitat requirements of key wildlife species for reclamation in the Mountain, Foothill, Boreal Forest and Aspen Parkland biomes within the Canadian Prairie provinces. As a result of funding limitations, the Prairie Grassland biome was not included in the Phase I study.

The second phase of the study involves the compilation of a concise, illustrated manual on reclamation of wildlife habitat. Methods of planning and implementation of wildlife habitat reclamation for all major biomes, including the Prairie Grassland biome, are described.

Funding for both phases of the study has been provided by the Alberta Recreation Parks and Wildlife Foundation, the Western Region of the Canadian Wildlife Service and the Western and Northern Region of the Environmental Protection Service.

PREFACE

Le présent rapport en deux volumes constitue le premier de deux volets d'une étude portant sur la restauration d'habitats fauniques dans les provinces des Prairies au Canada. Il fait la synthèse des données techniques qui ont été recueillies sur les formules et les méthodes de restauration des habitats fauniques (volume I) et donne un aperçu des besoins et des principales espèces fauniques en matière d'habitat pour la restauration des biomes, comme ceux des montagnes, des contreforts, de la forêt boréale et de la forêt-pré à trembles, situés dans la région des Prairies canadiennes. En raison de ressources financières limitées, le biome des Prairies n'a pu être inclus dans la première étape de l'étude.

Le deuxième volet a consisté en l'élaboration d'un bref guide illustré sur a restauration des habitats fauniques. On y explique les méthodes de planification et de mise en oeuvre de la restauration des principaux biomes, y compris celui des Prairies.

Les deux volets de l'étude ont été financés par l'Alberta Recreation, Parks and Wildlife Foundation, le Service canadien de la faune (région de l'Quest) et le Service de la protection de l'environnement (région de l'Quest et du Nord).

ACKNOWLEDGEMENTS

The compilation and synthesis of information in this report has involved the input and assistance of a large number of people. We would like to thank all of the individuals interviewed during this study for their time and cooperation. We would particularly like to thank G. Trottier, B. Munson, and K. Yonge for their continued input, support and direction. We also would like to thank the Coal Association of Canada, the Alberta Fish and Wildlife Division and the Reclamation Research Technical Advisory Committee (Alberta Energy and Natural Resources) for permitting us to extract several sections of the Wildlife Habitat Reclamation report for the Mountain-Foothills Reclamation Research Program for use in this synthesis. We would like to acknowledge J. Stelfox, E. Telfer and G. Trottier for their reviews of earlier versions of this report and K. Smyth for her assistance in compiling this report and editorial review. We also would like to thank A. Carriere for preparation of the typescript.

At the beginning of the study, the authors of the Phase I reports were employed by LGL Limited, environmental research associates in Calgary, Alberta. Although a corporate change by this company resulted in the transfer of this project to the newly-formed Delta Group, we gratefully acknowledge the support of the senior management of LGL Limited in the early development of the project concept and data assimilation.

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1.0 INTRODUCTION

During the harvesting extraction and transportation of renewable and non-renewable resources, natural forest and plant cover must often be removed, and in some cases, the organic and mineral soils are also disturbed. Consequently, the value of these areas for forestry, agriculture, recreation or wildlife is often severely diminished. The subsequent need for reclamation and revegetation in development areas is obvious and reclamation plans are presently a legal requirement of most resource development projects in Canada.

Four major end uses are commonly recognized as potential land use objectives for reclaimed land in non-urban areas: forestry, agriculture, recreation and wildlife. Prior to the past decade, forestry and agriculture were usually the only end uses considered for reclamation in the prairie provinces. However, wildlife end land uses have been receiving increased attention in recent reclamation planning as a result of better reclamation technology, increased government and public awareness of the importance of wildlife, the realization of the adaptability of wildlife habitat reclamation to a diverse range of reclamation situations, and the potential for reduced reclamation costs (Green and Yonge 1985).

Criteria for forestry and agriculture are well defined in the reclamation legislation and standards for the three prairie provinces. For example, the restocking guidelines of the Alberta Forest Service have been accepted as the minimum guidelines for a forestry end use for reclamation in previously forested sites in Alberta. Criteria for agricultural end uses in Alberta and Saskatchewan include guidelines for preserving the organic soils, restoring soil horizons, recontouring of the land surface, and application of specified grass seed mixes. In contrast, standard objectives for planning and implementation of reclamation for recreation or wildlife end uses have not been developed. For example, if wildlife habitat is proposed as a major end use for a reclamation area, what are the requirements of wildlife for plant diversity and species composition, topography, habitat diversity and interspersion, plant productivity, and water availability?

Although revegetation and reforestation techniques have advanced rapidly in the past decade, most reclamation programs have not considered the enhancement of wildlife habitat as an integral part of the reclamation plan. The failure to include wildlife end uses in reclamation is related to the lack of specific minimum criteria for wildlife as well as a poor understanding of the available methodologies for wildlife enhancement in disturbed sites, and the inability of reclamation planners to employ these techniques. Recent increases in public and government awareness of the economic, recreational, commercial, and aesthetic benefits of restoring wildlife habitat in disturbed areas is resulting in a more equitable consideration of a wildlife end use in some reclaimed areas. The technology is available and the climate is receptive to the development of guidelines for wildlife end uses in reclamation.

Wildlife end uses may often be one of the most viable and logical objectives of reclamation in many areas of the prairie provinces, particularly in the Boreal Forest region, where forestry and agricultural potentials are minimal and not economically viable. Even if a forestry, agricultural or recreational end use is the principal objective of a particular reclamation program, the creation or enhancement of wildlife habitat can always be included as a secondary or tertiary land use objective. Reclamation programs can often be modified to enhance wildlife habitat with only minor changes in planting regimes, contouring, and planning. Furthermore, inclusion of wildlife end uses in reclamation may not substantially increase the cost of reclamation and, in some cases, may reduce the cost.

The development of specific guidelines for wildlife enhancement will provide industry with another practical alternative in reclamation.

Although a considerable amount of research on enhancement of wildlife habitats has been conducted in the United States and several reviews of enhancement techniques for wildlife have been compiled, few attempts have been made to consolidate and define enhancement methodologies for wildlife in Canada. Of particular concern, no manuals for wildlife habitat reclamation are available to industry operators, reclamation planners or government which are directly applicable to the biophysical conditions in Canada.

Within the Aspen Parkland, Boreal Forest, Foothill and Mountain biomes of Canada, exploratory and extractive activities by oil sands and coal mining, conventional petroleum extraction and forestry have resulted in the loss of native wildlife habitat through site disturbances and linear right-of-ways. Because these losses will continue to increase with expanding industrial development, there is a need to consolidate information on wildlife habitat reclamation and enhancement and to determine the applicability of this technology to the specific biophysical conditions in these biomes.

In response to these needs for wildlife habitat reclamation, the Canadian Wildlife Service, the Environmental Protection Service of Environment Canada and the Recreation, Parks and Wildlife Foundation of Alberta undertook the development of a reclamation handbook for enhancement and creation of wildlife habitat in disturbed areas. The first phase of this study involves the preparation of a technical synthesis of information relevant to wildlife habitat reclamation in the Canadian prairie provinces (this report). The second phase of the study will involve the development and production of a concise reclamation manual for wide-scale distribution to industry and government.

1.1 STUDY RATIONALE AND BACKGROUND

Although the enhancement and protection of wildlife habitat is the legal responsibility of the Provincial and Federal governments, involvement of both private industry and government in wildlife habitat enhancement is a particularly productive and cost effective means of increasing present wildlife capabilities in many development areas. In an increasing number of cases during recent years, industry and government have had the opportunity and have shown a willingness to incorporate wildlife end uses in reclamation. However, such enhancement of wildlife habitat has been hampered by the lack of readily available technical information, the lack of specific reclamation criteria for wildlife end uses, and conflicting (and often superseding) demands with forestry or agricultural end uses. Development of specific criteria for wildlife end uses in reclamation and improved dissemination of information on reclamation of wildlife habitat will be important factors in consideration of wildlife habitat in reclamation.

Research on reclamation of disturbed areas and techniques for enhancement of wildlife habitat have progressed considerably in the United States since the enactment of the Surface Mining Control and Reclamation Act in 1977. Since then, a variety of studies have addressed the use of reclaimed areas by wildlife and the success of wildlife habitat mitigation. A small number of reviews have also summarized information on suitable methods for reclaiming wildlife habitat, primarily in the mid-west and eastern portions of the United States. Similar types of research in Canada, particularly western Canada, have been limited. Within the prairie provinces, various government and private agencies have been involved with wildlife habitat creation and enhancement. For example, the Canadian Wildlife Service (Poston and Schmidt 1981) prepared a handbook for improvement of wildlife habitat in the Prairie and Parkland region aimed primarily at acreage owners and farmers. Provincial fish and wildlife agencies also have initiated habitat improvement programs for ungulates, furbearers, waterfowl and raptors. The Alberta Fish and Wildlife Division recently released a series of habitat development fact sheets which include topics such as development of nesting islands, reclamation of sand and gravel pits for waterfowl and construction of fish ponds (Alberta Energy and Natural Resources 1985a,b,c). Ducks Unlimited has similarly sponsored numerous projects involving the creation, improvement or maintenance of wetland areas. However, few of these studies have involved reclamation areas or severely disturbed sites.

Several recently completed studies have provided summaries of enhancement and reclamation methodologies for wildlife but have focused either on specific types of disturbances or specific biomes within the prairie provinces. Hardy Associates (1982) reviewed some general methodologies for enhancement of wildlife habitat near construction sites. A literature review on methods of enhancing right-of-ways for wildlife has also been recently compiled for the Canadian Petroleum Association (Kemp 1985). A technical synthesis of potential and proven reclamation methods for wildlife habitat in the Mountain and Foothill biomes (Green et al. 1985a) was completed in early 1985 for the Mountain/Foothills Reclamation Research Program (MFRRP) which was jointly-funded by the Coal Association and Alberta Energy and Natural Resources. The latter report is similar to this study but is concerned only with reclamation in the Mountain and Foothill biomes. The MFRRP study also does not intend to develop a manual concerning wildlife reclamation techniques. However, the MFRRP program has generously permitted information from Green et al. (1985a) to be incorporated into this study in order that the Mountain and Foothill biomes as well as the Aspen and Boreal Forest biomes can be considered in both the technical report and the reclamation manual.

1.2 OBJECTIVES

The primary objectives of this program, as described in the Terms of Reference for the study, are to:

1. "Review and synthesize existing information on methods of enhancing wildlife in disturbed areas which are applicable to Boreal Forest, Aspen Parkland, Mountain and Foothill biomes in the prairie provinces." (Although the initial focus of the study was on Alberta, the similarity of biophysical conditions within the respective biomes allows extrapolation of results for the Aspen Parkland and Boreal Forest biomes to Saskatchewan and Manitoba.);

2. "Describe wildlife enhancement techniques for key wildlife species in each of the study biomes";

3. "Review and summarize existing reclamation legislation in western Canada"; and

4. "Prepare a manual for reclamation of wildlife habitat that is suitable for use by industrial, government and public reclamation planners. The handbook will define reclamation objectives for wildlife, enhancement methods for wildlife habitat, and minimum criteria for enhancement of wildlife habitat in each biome".

Objectives 1 - 3 will be addressed during the development of the technical report (Phase 1) whereas Objective 4 will be fulfilled by the development and production of a reclamation manual (Phase 2).

This two volume report is the final product for Phase I. Volume I (this report) summarizes the conceptual approach to wildlife habitat reclamation, methodologies for habitat reclamation, and potentially important criteria for development of reclamation guidelines. Volume II summarizes the important habitat requirements for key or representative wildlife species for each of the four biomes considered in this study.

2.0 METHODS

2.1 LITERATURE REVIEW

2.1.1 Wildlife Habitat Requirements

To effectively review and synthesize information on habitat requirements of all wildlife species occurring in the Boreal Forest, Aspen Parkland, Foothill and Mountain biomes would be a very labour intensive and costly exercise; moreover, much of the information would prove to be redundant as many species have similar or overlapping habitat needs. Consequently, the initial step in our literature review was to select "key" or indicator wildlife species for each biome. The key species concept is based on the premise that reclamation or enhancement of habitat for key species also will benefit other sectors of the wildlife community, even though reclamation methods are not aimed specifically at all of the wildlife species in the habitat. The key species approach therefore offers a means of simplifying the planning and implementation of wildlife habitat reclamation.

Based on this approach, six key species were selected for the Boreal Forest biome (beaver, muskrat, caribou, mule deer, moose and sharp-tailed grouse), five for the Aspen Parkland biome (red squirrel, beaver, muskrat, mule deer and sharp-tailed grouse) and ten for the Foothill and Mountain biomes combined (snowshoe hare, beaver, muskrat, caribou, moose, elk, mountain goat, bighorn sheep, spruce grouse and white-tailed ptarmigan). Further details of the selection process are provided in Volume II.

Habitat requirements summaries, based on existing reviews, biophysical models and primary literature developed in or applicable to the Boreal Forest, Aspen Parkland, Foothill and Mountain biomes (Figure 1), were prepared for each of the key species (see Volume II for detailed accounts). The objectives of the habitat requirements reviews were to illustrate the range of habitat features potentially required as an end product of reclamation or enhancement of habitat, and to provide a focal point for discussion and evaluation of available reclamation techniques.

A computer literature search of biological and ecological data bases was conducted using the key words food, diet, ecology, behaviour, and wildlife habitat in combination with both the scientific and common names of the ten key wildlife species. Initially we searched a large number of data bases including SCISEARCH, NTIS, Enviroline, Environmental Bibliography, Dissertation Abstracts on Line, CAB Abstracts, and Biosis Previews. However, as there was considerable redundancy in the references produced, these subsequently were narrowed down to NTIS, Dissertation Abstracts on Line, and Biosis Previews. We also manually searched the Canadian Wildlife Service (Western Region) Library, the Alberta Energy and Natural Resources Library, the Alberta Environment Library, the Fish and Wildlife Division Library, and the thesis collection and libraries at the University of Alberta for relevant unpublished reports. Additional unpublished information was obtained from the LGL Limited library, the personal libraries of LGL Limited biologists, and from persons consulted during interviews.

2.1.2 Reclamation Techniques

Current published information on wildlife habitat reclamation techniques was obtained through use of a computer literature search of the RECLAIM data base, review of several recent bibliographies on reclamation (Sims and Powter 1982; Sims et al. 1984) and manual searches of the libraries described above. As a considerable amount of literature had been assembled prior to the start of this study, we also obtained a number of publications through cross-checking of the literature cited in these publications. Additional references were obtained during interviews with reclamation specialists.

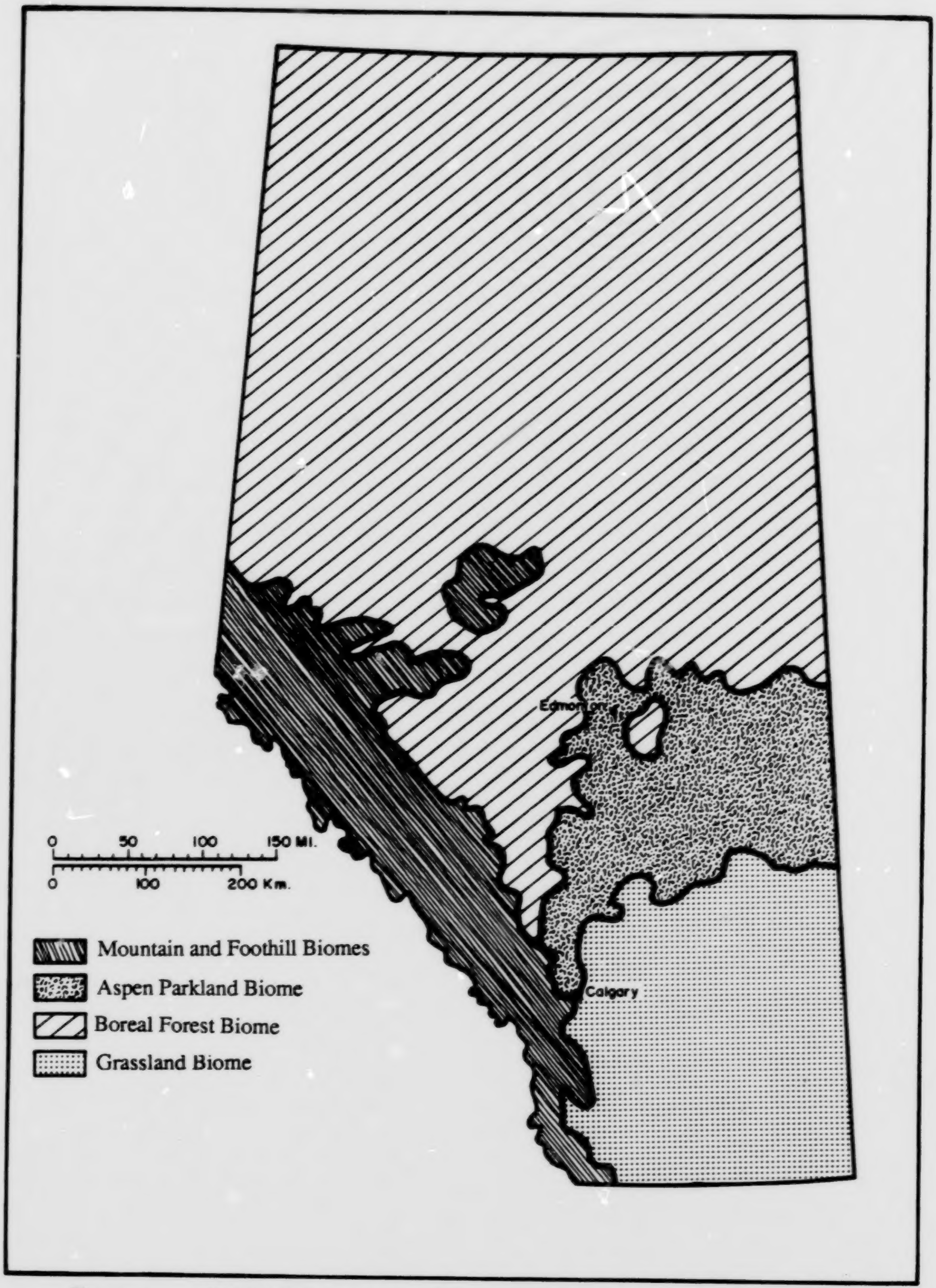
0
50
100
150 MI.
0
100
200 Km.
Mountain and Foothill Biomes
Aspen Parkland Biome
Boreal Forest Biome
Grassland Biome
Edmonton
Calgary

Figure 1. Wildlife habitat regions of Alberta (Source: Knapik and Westworth).

2.2 INTERVIEWS

Because interest in wildlife habitat reclamation has developed only recently, a considerable amount of information on reclamation and revegetation techniques, wildlife requirements and reclamation standards is available only through interviews with reclamation and wildlife experts. Interviews were conducted with a variety of industry, government and consulting reclamation specialists in Alberta, British Columbia, Saskatchewan, Washington State, Idaho, Montana and Wyoming. With the exception of people contacted in Edmonton, Calgary and Regina most of the interviews were conducted by telephone. A list of the persons contacted, their affiliation and date of contact(s) is provided in Appendix 1.

2.3 SCIENTIFIC NONMENCLATURE

Common names of plants and animals are used in this report as much as possible. Plant, mammal and avian nonmenclature generally follows Moss (1959), Banfield (1974) and Salt and Salt (1976), respectively. If no common names were available for a species, we have used the scientific name as described in the references cited above. A list of common names and scientific equivalents is provided in Appendix 2.

3.0 CONCEPTUAL APPROACHES IN WILDLIFE HABITAT RECLAMATION

3.1 BASELINE INFORMATION AND PRE-PLANNING

When attempting to reclaim or enhance wildlife habitats on a reclamation site, there are a number of factors that should be considered during the design and implementation stages of the reclamation plan. Prior to development, information should be obtained on the wildlife habitats and populations in and adjacent to the site. Information on the abundance, distribution and diversity of wildlife; special wildlife uses in the area; the abundance, composition and distribution of vegetation communities; the interspersion of habitat types; and the availability of water and topography provide a framework for development and reclamation plans (Barr Engineering and Borovsky 1980; Dickson and Vance 1981; Snyder and Potter 1981; Proctor et al. 1983). For example, information on vegetation communities can be used to select appropriate plant species for reclamation and to assist in the design of the reclamation landscape. Important ecotypes of native vegetation can also be identified and material obtained for propagation (e.g., shrub cuttings; native seed, shrub clumps). Information on wildlife populations also will be useful in selecting key wildlife species for the reclamation plan.

If wildlife habitat is to be a primary end use for a site and the reclamation project is to provide the greatest benefit at the lowest cost, the creation and enhancement of wildlife habitat should be considered in the development and reclamation plan prior to developing and operating the site (Herricks and Sale 1978; Proctor et al. 1983; Green and Yonge 1985).

Pre-planning for wildlife habitat reclamation should identify natural features on the site such as units of natural forest or shrub cover, riparian areas, water bodies and rock outcrops that are of high value to wildlife but that will not impede movement of equipment or use of the site because of their location (Proctor et al. 1983; Green and Yonge 1985). For example, forested strips (30-100 m wide) can be left along water courses to provide a movement corridor for wildlife, to preserve riparian habitats and to reduce erosion of soils and sedimentation of the stream. Strips of natural tree and shrub cover can also be used to screen haul roads, access roads and major activity areas. Maintenance of adjacent cover will promote wildlife use of reclaimed areas, particularly along the forest edge, and will encourage invasion of native plant species.

Integration of wildlife habitat reclamation during the pre-development phase also allows some areas of the site to be designed for wildlife with little or no extra cost. This is particularly true for some sites that involve requirements for large materials movements, recontouring or watershed development. For example, the shape of overburden piles can be readily modified to include a variety of slopes and aspects and rough terrain which, in turn, provide a diversity of micro-habitats for plant community development (e.g., Kerr MS; Proctor et al. 1983). In flatland areas or on shallow slopes, the overburden pile can also be oriented to provide shelter from prevailing winds and southern exposures for relatively snow-free areas during the winter. Features such as highwalls can be planned to blend with existing landscape features (e.g., WECO 1982); end pits (the last excavated pit within a mine site) can be flooded with water from local streams or drainage ditches to form ponds or lakes; or below-grade haul-roads (ramps) can be converted to coulee habitats.

3.2 BIOLOGICAL CONCEPTS

Successful enhancement of disturbed areas for wildlife must provide the basic requirements for food, water, cover, and range. Consequently, reclamation for wildlife should consider plant diversity, species composition and interspersion, habitat dispersion and edge habitats, water regime and proximity to water, and topography. In some cases, line-of-site exposure and isolation from human disturbance may also be important considerations. Generally, an area with a diversity of habitats is capable of supporting a greater variety of wildlife than areas with a limited number of plant communities (Thomas 1979a). Diversity is the key to successful reclamation of wildlife habitat, and reclamation programs for wildlife habitat should strive to maximize the diversity of naturally-occurring vegetation communities, water resources and topography within the local region of the development while still fulfilling the important habitat requirements of the selected key species of wildlife. Once these communities are established, natural ecological processes should be allowed to direct successional trends in the plant community.

To be successful and economical, wildlife reclamation programs must pre-plan and integrate post-development topography, surface and ground water hydrology and revegetation. Maintenance of any pre-disturbance habitat features that will not unduly restrict the development of the site (e.g., vegetation islands, rock outcrops, water bodies and watercourses) will also improve the site value to wildlife. Reclamation programs which incorporate a holistic community approach to reclamation are much more likely to benefit wildlife in the long-term than are piece-meal approaches to reclamation. Development of plant communities must not only involve the selection of suitable plant species and planting configurations but also the placement of these communities in appropriate microsites that meet the community's requirements for features such as soil texture and chemistry, slope and aspect, ground and surface water hydrology, wind exposure, and elevation.

Wildlife ecology and habitat use can involve a complex array of interspecific and intraspecific relationships and, as a result, methodologies for enhancement of wildlife habitat can also become complex. To simplify the objective of establishing a diversity of self-sustaining plant communities, reclamation of wildlife habitat should be initially directed towards the rapid establishment of early seral plant communities (i.e., 1-15 years after establishment) that are of benefit, in the short term, to wildlife species adapted to early seral communities (Green and Yonge 1985). There are several advantages to this approach:

1. Plant associations in early seral communities are floristically more simple than in mature or climax communities and, as a result, reclamation requirements for re-establishing these communities are less complex;

2. The establishment of early seral vegetation communities is a realistic and attainable goal for reclamation and, within a relatively short term, provides a means of evaluating the wildlife enhancement program. (In contrast, a program to develop a mature plant community will involve a complex array of enhancement methodologies and, because the results may not be evident for 50-100 years or more, it will be extremely difficult to evaluate the success of the program);

3. Early successional wildlife species will respond to, and are most likely to benefit sooner from, the re-establishment of plant communities in reclamation areas than wildlife species that are adapted to more mature plant communities;

4. By promoting the development of early seral plant communities, we will also accelerate plant succession towards more mature, stable plant communities and, hence, will indirectly benefit those wildlife species that depend on these habitats (Iverson and Wali 1978; Bradshaw 1984); and

5. Because results of the program will be evident in a relatively short period (<15 years), there is positive psychological feedback to industry which will likely encourage continued or increased participation in enhancement of wildlife habitat.

Although the major focus of a wildlife reclamation program may be the establishment of early seral communities, where appropriate, methods which promote rapid succession towards mature plant communities should also be considered. This is particularly true for watershed and wetland re-establishment , where edaphic climaxes such as emergent or riparian communities are a desired habitat type. Although reclamation of these communities may require decades, reclamation programs can focus on the establishment of appropriate pioneering communities to promote the development of edaphic climax communities.

3.3 BIOPHYSICAL REGIONS

Five biomes comprise most of the prairie provinces -- the Boreal Forest, Aspen Parkland, Prairie Grassland, Foothill Forest and Mountain biomes -- all of which are subject to some degree of industrial development. The main emphasis of the Phase I information review and synthesis has focused on the Aspen Parkland and Boreal Forest biomes. Information on wildlife habitat reclamation in the Mountain and Foothill biomes is extracted, with revisions, from the MFRRP study (Green et al. 1985a). The Phase II manual for this study will include information for all of these biomes except the Prairie Grassland. The Grassland biome has been excluded primarily because of the budgetary need to reduce the scope of the study. The need for wildlife reclamation guidelines in this biome was considered least critical because (1) reclamation in this biome generally emphasizes exclusive agricultural end uses; (2) most losses of wildlife habitat in this biome are associated with agriculture rather than with industry and there are currently no reclamation requirements for agricultural disturbances; and (3) the distribution of wildlife habitat in this biome is restricted, hence there is a lower probability in this biome than in the other four biomes that an industrial development will intersect a block of wildlife habitat.

3.4 KEY SPECIES

A large number of wildlife species may be present on, or potentially utilize, reclamation sites and edge habitats around a site (e.g., Verts 1959; Voight and Glenn-Lewin 1979; Brenner et al. 1980; Whitmore 1980). To design a reclamation plan that will adequately fulfill the habitat requirements of all of these species would difficult to attain. Therefore, one of the essential steps in developing practical reclamation programs for wildlife habitat is the selection of key wildlife species. The key species concept (USFWS 1980) provides a clear conceptual framework for reclamation of wildlife habitat by focusing on the habitat requirements of selected species of wildlife that are representative of various habitat strata within a local area. By improving habitat for key species, other components of the wildlife community will benefit even though reclamation will not be aimed specifically at all of the wildlife species that may potentially occupy a site (Green and Yonge 1985).

As a general guideline, key species should be of socio-economic and ecological importance and should represent the habitat requirements of several other species of wildlife. Several key species were selected for each of the four biomes considered in this study and together represent most of the major habitats and habitat strata within the biome. Key species were selected based on a four-step process (Green et al. 1984):

1. Identification of resident and seasonal wildlife species having strong affiliations to the Aspen Parkland, Boreal Forest, Foothill or Mountain biomes;

2. Identification of groups or associations of species (birds and mammals) with similar habitat requirements (i.e., guilds);

3. Evaluation of the political, socio-economic and ecological significance of the species in each of the species associations; and

4. Selection of key species from each of the wildlife guilds based on numeric scores for each of the above evaluations.

Details of the selection process for each of the study biomes are provided in Volume II. Key species for each of the study biomes are:

Boreal Forest Biome	Aspen Parkland Biome	Mountain and Foothill Biome
Beaver	Beaver	Beaver
Caribou	Mule Deer	Caribou
Moose	Muskrat	Elk
Mule Deer	Red Squirrel	Moose
Muskrat	Sharptail Grouse	Mountain Goat
Sharptail Grouse		Mountain Sheep
		Muskrat
		Snowshoe Hare
		Spruce Grouse
		White-tailed Ptarmigan

Because of the overlap of the selected key species for the Mountain and Foothill biomes, key species for these two biomes have been combined. Reclamation methods for key species within each biome are summarized later in this report. Literature reviews on the important habitat requirements of each key species are provided in Volume II.

Because of the pivotal role of key species in structuring and implementing a reclamation plan for wildlife, key species must be selected on a site-specific basis. One or several of the key species for a biome should be selected for a site based on:

1. Baseline information on wildlife distributions and abundance prior to and during the site disturbance. In most cases, the reclamation plan should be directed towards those key species which represent wildlife that were common on the site prior to disturbance and are still present in natural areas adjacent to the site;
2. Regional wildlife management plans. Wherever possible, reclamation plans for wildlife should complement regional wildlife management goals of the provincial fish and wildlife agency; and
3. The types of habitats that can be practicably restored on the site.

Although the primary function of the key species is to determine the appropriate reclamation procedures for a site, key species can also be used to monitor the progress of the reclamation program in creating wildlife habitat. For example, the quality and quantity of moose habitat on a reclamation site could be compared to moose habitat prior to disturbance or moose habitat adjacent to the reclamation site.

3.5 INTEGRATION OF RECLAMATION END USES

The four major end uses for reclamation sites -- forestry, agriculture, wildlife, and recreation -- need not represent exclusive end uses. It is likely that one or more end uses will be appropriate for a specific reclamation area. In some cases, wildlife habitat will be the primary end use but in other cases, forestry or agriculture will be the primary end use and wildlife habitat will be of secondary importance. In these instances, it may be possible to alter the reclamation plan for the primary use to still provide some benefits to wildlife. For example, restocking guidelines for a forestry end use in the Foothill biome might be altered to permit the development of small habitat blocks or interplanting of important food shrubs to provide more suitable habitat for ungulates and upland game birds. Similarly, contouring of reclamation sites in the Aspen Parkland biome could create some wetland areas for wildlife while still providing moderately shallow and smooth slopes for agriculture. In addition, problem sites within forestry or agricultural reclamation areas (e.g, rock outcrops, lowland depressions) can often be developed for wildlife at lower costs than rehabilitation of these sites for the primary end use. The choice of appropriate end uses for a disturbed site and the degree of integration among these end uses will depend on sociological, economic and ecological values in the region and the practicality of the end use objectives. Although some reclamation sites are best developed exclusively for wildlife (e.g., riparian zones, marshlands, shrub meadows), if multiple end uses are selected for a site, they should be integrated as much as possible in the reclamation plan in order to maximize the benefits of reclamation to society.

4.0 EXISTING RECLAMATION LEGISLATION AND STANDARDS[1]

4.1 ALBERTA RECLAMATION LEGISLATION

The Alberta Land Surface Conservation and Reclamation Act (LSCRA) addresses the conservation and reclamation of land disturbance. Several regulations associated with the LSCRA, also affect reclamation programs:

1. Land Conservation Regulations (1974; amended 1976);
2. Regulated Coal Surface Operations Regulations (1974); and
3. Security Deposits Regulations (1974).

The LSCRA is one of the few Acts in Canada that deals exclusively with the reclamation and conservation of land (Marshall 1983). The Land Conservation and Reclamation Division, Alberta Environment is responsible for administering the act. The LSCRA provides an orderly six-stage process for review and approval of applications for reclamation orders and certificates of approval. These stages include submission of a development and reclamation plan, approval of the development and reclamation plan, posting of a reclamation bond, issuance of reclamation orders if reclamation work fails to obtain approval, issuance of surface control orders if an operator fails to comply with the reclamation orders, and issuance of a reclamation certificate if reclamation efforts meet the standards with subsequent return of the reclamation bond (Harrington 1979). For mine developments, security deposits may involve a cash deposit of $5,000 - $25,000 depending on the size of mine or, at the discretion of the Minister of Environment, a security deposit based on a rate/tonne may be established (current levies range from $0.25 - $2.00/tonne) (Marshall 1983).

As a result of a industry-perceived need for greater flexibility in reclamation standards, the Guidelines for the Reclamation of Land in Alberta (ALCRC 1977) were issued in 1977 and are currently being amended. The guidelines provide direction and establish minimum requirements for drainage and erosion control, conservation of reclamation materials (e.g., topsoil), backfilling and recontouring, restructuring of the root zone, restoration of service and utilities, and post-mining land management. The guidelines address revegetation of wildlife habitat as follows:

> "Where the prescribed post-disturbance land use is the establishment of permanent vegetation suitable for wildlife habitat, the operator is responsible for the establishment of various species and numbers of trees, grasses, forbs and shrubs of a density and composition which will provide food and cover for wildlife, consistent with the ecological zone of the region and satisfactory to the Approving Authority." (ALCRC 1977)

Wildlife habitat reclamation is also indirectly addressed in terms of drainage and erosion control, backfilling and recontouring (e.g., highwalls), and restructuring of the root zone.

Mining developments in the mountain and foothills biomes also are affected by the Coal Policy and the Policy for Resource Management of the Eastern Slopes (AENR 1977, draft revisions 1984). In the latter policy, eight land use areas were identified in the eastern slopes with different restrictions on mining and operating conditions.

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[1] This section has been extracted with modifications from Section 10.0 of Green et al. (1985).

4.2 RECLAMATION LEGISLATION IN ADJACENT PROVINCES, TERRITORIES AND STATES

In British Columbia, mine reclamation is governed by the Mines Act (Marshall 1983) which provides the legislative framework for mine development and reclamation. More specific, yet flexible guidelines have been established for major mines (Mine Reclamation Guidelines 1984), and coal and mineral exploration (B.C. Ministry Energy, Mines and Petroleum Resources 1982a, 1982b). Draft guidelines have been formulated but not implemented for reclamation of wildlife habitat (Foubister 1982).

Development and reclamation in Saskatchewan are within the authority of the Environment Act but, as yet, no formal reclamation regulations have been approved (draft regulations were prepared in 1976 and have subsequently been used as guidelines in preparing reclamation guidelines) (Marshall 1983; S. McLeod pers. comm.). Policy directives, environmental impact assessment procedures and permit/lease approval systems are usually employed to direct reclamation programs and enforce reclamation requirements. For example, reclamation guidelines have been developed for the Coronach and Estevan areas (Saskatchewan Environment 1983, 1984).

On federal lands north of the 60th parallel, reclamation requirements for most land-based activities are defined in the operating conditions attached to the land use permit issued by Indian and Northern Affairs under the Territorial Lands Act. Mining operations are regulated in a similar fashion under the Canada Mining Regulations. Reclamation requirements are generally based on returning abandoned sites to a physically stable regime, with no loss of water quality in adjacent watercourses and bodies. For larger industrial activities, particularly in the oil and gas sector, permitting may involve review of all environmentally-related project information by the Environmental Assessment Review Process which may advise the originating federal government department on specific items concerning reclamation and wildlife habitat.

In Idaho, land reclamation for mining is governed by the Idaho Surface Mining Act (Cushwa 1980; L. Jones pers. comm.). The act requires the submission of a mine development and reclamation plan which is reviewed and approved by the State Board of Land Commissioners. If important fish and wildlife habitats are disturbed, the plan must meet the approval of the Department of Fish and Game. In terms of specific concerns for wildlife habitat reclamation, vegetation communities growing on the site prior to mining must be restored. Some requirements for recontouring overburden and tailings pond development indirectly affect habitat reclamation.

Reclamation legislation in Montana includes some of the most rigorous and specific laws and guidelines in the United States or Canada. Mine reclamation is governed by the Montana Strip Mining and Reclamation Act (1973), the Montana New Hard Rock Law (1974), and the Strip Mine Coal Conservation Act (1973) (Cushwa 1980). The Montana reclamation laws require detailed pre-mine inventories of topographic features, vegetation and wildlife which are used as post-mine evaluation criteria. Reclamation of the site is required to return the topographic and vegetation diversity to pre-mining levels with subsequent restoration of wildlife habitat.

4.3 FORESTRY STANDARDS AND INTEGRATION WITH WILDLIFE

From the perspective of the forest industry, forested areas can generally be divided into two categories: forests that are suitable for commercial timber production and forests for non-commercial uses such as wildlife habitat, watershed protection and recreation (Millson and Bondy 1984). Although commercial timber production in an established forest is not exclusive of the latter three uses, reforestation guidelines for commercial timber are quite different from reforestation practices for wildlife habitat or recreation, and hence may alter the value of reforestation areas for these alternative uses. In particular, planting regimes for commercial timber focus primarily on monocultures of commercial tree species whereas planting regimes for wildlife and recreation should preferably emphasize a high diversity of trees, shrubs and ground cover.

The reforestation requirements of the Alberta Forest Service (AFS) are the most stringent of the three prairie provinces; the discussion below has focused primarily on the regulations of the AFS on the assumption that similar principles are applicable in the other prairie provinces. The AFS considers land to be suitable for commercial timber production if the area is stocked with commercial tree species and is potentially capable of producing a minimum of 50 m^3/ha gross timber volume at the end of a 120 year rotation period (Millson and Bondy 1984). Commercially-acceptable trees include spruce, pine, fir, larch, poplar (including aspen), and birch. Because these forest types also are of value for the maintenance of wildlife productivity and diversity, the potential exists for the integration of forestry and wildlife end uses on these lands.

The Alberta Forest Regeneration Survey Manual (AFS 1979), which provides restocking standards for timber management areas, has been used as a forestry reclamation standard for mine areas occurring on productive forest land. An area harvested primarily for the removal of coniferous timber is considered to be satisfactorily restocked when:

1. "60% or more of the sample plots are stocked with acceptable established coniferous seedlings, the stocked plots being evenly distributed over the sample area", or

2. "60% of the sample plots are stocked with acceptable established coniferous seedlings and an additional 20% of the sample plots are stocked with acceptable established deciduous seedlings and/or balsam fir and alpine fir, either individually or in the aggregate. The stock plots must be evenly distributed over the sample area." (AFS 1979)

The area to be reforested (or reclaimed) "cannot contain any areas larger than 10 acres in extent which do not in themselves meet the required stocking standard". In addition, "identifiable areas larger than three acres which in themselves do not meet the required stocking standard must not in aggregate exceed 20 percent of the total area to be classified" (AFS 1979). Given that forestry is the primary land use objective, these guidelines provide opportunities for two major types of integration of wildlife end uses with forestry:

1. Interplanting of shrub and herb communities for wildlife with commercial tree species within the areas designed for commercial timber production (i.e. in forestry areas, this must be an aggregate total of at least 80 percent of the reclaimed area); and

2. Assuming that 80 percent or more of the reclamation site must be returned to commercial timber, the remaining area (up to 20 percent of the site) could potentially be reclaimed specifically as habitat for wildlife.

It is recognized that, in some areas of exceptional wildlife habitat (e.g., ungulate winter range), integration with forestry may not be desirable or possible. For example, tree establishment should be minimized on southeastern to southwestern aspects that could be developed as open shrub and meadow communities for winter feeding sites for ungulates. In areas adjacent to escape terrain for bighorn sheep or mountain goats, tree establishment should similarly be discouraged.

4.3.1 Interplanting

In natural successional areas, tree, shrub and ground cover co-establish and develop as holistic forest communities. Current reforestation practices, however, strive to maximize wood production and generally discourage the development of shrub or herb/grass understories (D. Dempster, pers. comm.). Scarification, slash burning, and herbicide applications are utilized to promote tree growth, often at the expense of other components of the forest ecosystem (AFWD 1978).

Although some areas are best suited for reclamation, primarily to a forestry end use, interplanting of deciduous tree, shrub and some ground covers with commercial timber species could greatly improve the value of reforestation areas for wildlife. Selection of the key wildlife species and, in turn, the selection of plant species for interplanting, should consider the implications for wildlife damage to commercial tree species. Potential for competition among the commercial tree species and the interplanted species also should be reviewed.

The seedling stocking rates for commercial tree species generally require a 2.5 - 3.0 m spacing between individual plants and are based on the need to control competition for water and nutrients among the seedlings. As a result, interplanting of non-commercial trees and shrubs must either displace commercial tree seedlings or potentially increase interspecific competition for nutrients and water. However, casual observations of reduced wildlife damage on some conifers when interplanted with other tree and shrub species, suggest that some benefits to growth and survival of commercial tree species may be realized as a result of interplanting (V. Betts, pers. comm.). In addition, some species of native ground covers and shrubs (i.e, alder, snowberry, buffalo berry, locoweed, hedysarum, cicer milk vetch, and wild vetch) provide important sources of wildlife forage or browse and are capable of producing natural sources of soil nitrogen which, in turn, may benefit timber production (J. Stelfox, pers. comm.). Some of the ground cover species such as alfalfa, red clover and alsike clover that are commonly used in current revegetation programs on disturbed sites provide highly palatable forage for wildlife and are also capable of fixing nitrogen. Conclusive evidence of these benefits to forestry is lacking and further research is required (Sims et al. 1984). Should such benefits exist, there may be an advantage in reducing the stocking rates of commercial seedlings to allow for interplanting of other trees, shrubs and ground covers; the lower density of commercial seedlings may be compensated by increased vigour and survival.

4.3.2 Development of Small Habitat Blocks

Within a reforestation area, sites such as waterbodies, watercourses, seeps, cliffs and steep slopes are not considered to be productive forest land and can potentially be developed or enhanced for wildlife use. In addition, portions of the productive forest land could conceivably be modified for wildlife use, within the current constraints of the Forestry Restocking Guidelines, as long as individual areas do not exceed 4 ha (10 acres) and the aggregate total of these areas with sizes over 1.2 ha (3 acres) do not exceed 20 percent of the total reclaimed area. These latter areas for wildlife might include important habitat features such as riparian zones, southeastern to southwestern slopes for winter foraging sites, or shrub clumps. Wildlife habitat reclamation in these areas can incorporate some or many of the techniques described in Section 6.0. However, the selection of the key species for reclamation in these sites should take into account and limit the potential of the selected guilds to interfere with or damage forest crops.

No examples of developing small units of wildlife habitat within commercial timber areas are known for the prairie provinces. Because these measures may be viewed as reducing forest productivity, use of habitat blocks may be questioned by the forest industry. It is conceivable, however, that growth and survival of commercial species could be enhanced by these measures, particularly if enhancement of small areas for wildlife were to reduce amounts of wildlife damage to the commercial species. For example, many deciduous shrubs are highly preferred as browse by ungulates in comparison to the commonly-planted commercial species of conifers (e.g., spruce, pine and fir). No quantitative data are known which show negative or positive effects of wildlife integration with commercial forestry and further research on this topic is recommended.

4.4 AGRICULTURAL STANDARDS AND INTEGRATION WITH WILDLIFE

Reclamation standards for agricultural land in the prairie provinces require that the reclamation program return disturbed land to productive use. Guidelines have been developed for re-grading of the land surface, surface drainage, top-soil handling and replacement or reconstruction of soil horizons and revegetation. Most developments are now required to stockpile separately topsoil and overburden. Following completion of activities, overburden material is replaced, recontoured to complement surrounding land contours and drainage and capped with a specific depth of top soil. Fertilizer amendments and nurse crops are generally utilized for several years before the site is released for public use.

Land reclaimed for agriculture may be used for crop production, forage production and/or grazing. Because the former two uses involve intensive land management practices, opportunities for integrating wildlife habitat reclamation and agricultural reclamation within the same land area are small. Most opportunities for wildlife habitat reclamation within agricultural lands will involve problem reclamation sites such as settling ponds, end pits, areas of poor soil that are inadequate for agricultural use, rock outcrops or steep slopes. Hedgerow re-establishment will also provide opportunities for wildlife habitat reclamation. Anderson and Markham (1981) review a number of potential methods of integrating agriculture and wildlife reclamation.

Because of the shortage of tree and shrub cover for wildlife in most agricultural areas, reclamation for wildlife in these areas should include the creation of small shrublands and woodlots. In addition, because of the importance of wetlands for waterfowl production throughout much of the prairie provinces, creation or enhancement of ponds should be incorporated whenever possible. If wetlands are created for waterfowl, adequate areas of tall grass meadow must be available directly adjacent to the pond in order to provide suitable nesting habitat.

However, some agricultural uses of these upland grass communities can be integrated with wildlife uses through seasonal separation of agricultural activities and periods of sensitive or critical wildlife use. For example, grass meadows can be hayed or used as part of a rotation grazing scheme with few impacts on waterfowl if agricultural use is restricted to the mid-July to early August period. By the start of this period, most nesting and brood rearing activity is complete yet there is still sufficient time for regrowth of the ground vegetation to provide adequate nesting cover during the following spring.

4.5 IMPORTANT CONSIDERATIONS FOR PLANNING AND ASSESSMENT OF WILDLIFE HABITAT RECLAMATION

During the interviews of government and industry specialists and review of literature for this study, a number of common concepts concerning desirable attributes of assessment criteria and planning methods were discussed, including:

1 A clear definition of the reclamation requirements. Reclamation criteria must clearly state the required reclamation objectives, the process for establishment of a standard, and the process for comparing the site conditions with the standard. Clearly defined criteria allow the project proponent to develop a comprehensive reclamation plan to achieve the required end goals and to identify and correct deficiencies prior to assessments;

2. The evaluation process should be easy to conduct;

3. The criteria must be flexible to site variability. Although general province-wide standards may be developed, the criteria must allow for adaptation to the specific physical, climatic and biological conditions of the site;

4. The criteria must be adaptable to multiple land use objectives. Because wildlife end uses can and may often be integrated with other land uses (e.g., recreation, forestry, grazing), the criteria must allow for adaptation to multiple land use;

5. The criteria must allow for input from management agencies. Wildlife habitat reclamation permits government management agencies to enhance regional management plans. Regardless of pre-development land uses, the criteria should allow for modification of the final land use to complement or directly influence regional management plans for one or more wildlife species;

6. The criteria must ensure that wildlife habitat has been successfully re-established. The criteria should provide accurate assessments of habitat quality and compare these to an accepted standard which is representative of high quality wildlife habitat within the region;

7. The criteria should minimize the time period prior to assessment. Because of the financial cost of posting a reclamation bond, industrial interests prefer criteria which minimize the assessment period. Because minimization of this period requires predictive assessment, the criteria must provide a high assurance of reclamation success; and

8. The criteria should specify procedures for remedial reclamation in the event of failure. In the event that reclamation on a site does not meet the planned objectives, procedures for identifying and correcting deficiencies should be discussed. Provisions for post-assessment/certification failures also should be described (e.g., designation of responsibility, actions).

5.0 EVALUATION TECHNIQUES FOR WILDLIFE RECLAMATION[1]

Wildlife habitat reclamation primarily involves the manipulation and management of vegetation communities and assessment of reclamation success must therefore involve direct or indirect evaluations of habitat quality. Habitat quality can be assessed utilizing one of two possible approaches: population-based and habitat-based assessments. The utility of these approaches in evaluating reclamation success, particularly as they apply to the development of reclamation guidelines or standards, are reviewed briefly below.

In reviewing assessment methodologies, we have assumed that the objective for wildlife habitat reclamation is the restoration of an equal or greater amount and/or quality of habitat than existed prior to disturbance. This may be achieved through enhancement of quality and/or habitat quantity, and in some cases, may involve changes in the habitat composition and diversity on a site. For example, consider a proposed development site where elk are the most abundant large mammals and have been recognized as an important wildlife management concern. If the development is to remove climax forest communities, and if winter foraging areas are suspected of limiting local elk populations, southeastern to southwestern aspects within the reclamation site should be reclaimed to open meadow communities that are suitable as winter foraging range.

Regardless of the selected land use for wildlife, it will be necessary to assess the pre-development conditions of the site and the regional conditions in order to determine a range of values or a standard for reclamation. The pre-development assessment can also provide information on animal abundance, existing vegetation communities and wildlife use of these habitats which, in turn, can provide information valuable to the development of the reclamation plan (e.g., selection of key species, selection of appropriate plant communities or species). Therefore, we have assumed that assessments of reclamation success will require field surveys prior to development, as well as following establishment of the reclamation site.

5.1 POPULATION ASSESSMENTS

Population-based assessments provide indices of animal densities (or absolute numbers) and species diversity, which are generally assumed to be directly and positively related to habitat quality (Van Horne 1983). A broad range of techniques are available to provide estimates of population density or species diversity in mammal and bird populations; a review of these census methods is beyond the scope of this report, and will not be addressed here. Regardless of the census methods, population-based assessments generally assume that areas with higher densities of animals or a higher species diversity are better quality habitats than areas with lower densities or diversity (Van Horne 1983).

Population-based assessments for reclamation success can be misleading because the assumed relationship between animal density and habitat quality is not always valid. Factors that may invalidate this assumption include census accuracy, seasonal variation, behavioural responses, cyclic population changes and extrinsic or off-site factors. Furthermore, since reclamation sites may often represent only a small portion of the home range or seasonal range of large wildlife species, interpretation of population data for such relatively small sites may be of questionable value for reclamation assessments.

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[1]. **Portions of this Section have been extracted from Green et al. (1985)**

If population density is to be related to habitat quality, abundance estimates must be accurate and precise to ensure that a standard can be developed and that site densities can be compared to the standards. All sampling techniques designed to estimate animal abundance are subject to certain biases and inaccuracies, particularly if an animal is migratory, difficult to observe or has a clumped distribution (e.g., animals in herds or flocks). To improve the accuracy and reliability of these estimates, the sampling intensity must be increased both in terms of time and area. Such an increase in sampling intensity is often associated with prohibitively large increases in sampling cost.

Habitat-specific densities can also differ by season and among different wildlife groups. For example, winter habitat in the prairie provinces is critical to the survival of many larger species of mammals, particularly ungulates, whereas spring breeding and nesting habitat are essential components of waterfowl habitat. As a result, population-based assessments would have to recognize these seasonal and interspecific differences in habitat use and provide adequate sampling to account for these differences.

Additional factors that can influence the validity of population-based assessments are behavioural responses or social interactions. In territorial species, dominant animals can prevent subordinate animals from utilizing an area or can suppress reproduction of subordinates in high quality habitat (e.g., bighorn sheep) (Van Horne 1983). In some cases such as small mammal populations, subordinate animals may emigrate to habitat "sinks" and densities in these sinks may exceed densities in the higher quality habitat (Lidicker 1975). As a result, densities in lower quality habitat may sometimes be greater than in better quality habitat (Van Horne 1983).

External factors, unrelated to a site, can also influence animal densities. Predation or disease in undisturbed areas around a reclamation site may reduce animal numbers and restrict animal immigration to a site, regardless of habitat quality on the site. For example, a recent lungworm epidemic in southwestern Alberta and southeastern British Columbia substantially reduced numbers of bighorn sheep in the region and sheep are now absent from some of the formerly occupied range (W. Wishart, pers. comm.). Absence of bighorn sheep in the vicinity of the Fording Coal mine has been attributed to this decline (D. Lane, pers. comm.). The absence or low numbers of animals on a site may also reflect a cyclic population change rather than poor quality habitat. Population cycles have been documented in some rodent and lagomorph species in the prairie provinces (see review by Green [1979]) and may occur over the longterm in some species of larger mammals and some species of birds.

Because population-based estimates of habitat quality are easily influenced by external factors unrelated to habitat quality and may be biased by the size of the reclaimed area in relation to the home range or seasonal range of the key species, it may be difficult to interpret survey results and to compare them to the objectives of the reclamation plan. In the event of low abundance, and, presumably, poor habitat quality, the factors associated with the poor ranking also are not readily apparent. Poor quality could be related to the absence or inadequacy of specific habitat features, the effects of external factors that influence population densities, or a combination of these two effects. Since population-based assessments are an indirect measure of the ability of a reclamation program to replace or create habitat features, they do not provide an easy means of identifying problems in the reclamation program.

Although population assessments may not be the best means of evaluating reclamation success, they are an important component of the baseline environmental assessment for a development. Data on the diversity, distribution and abundance of wildlife on and adjacent to the development site are essential for identification of potential key species, placement of vegetation communities (e.g., to complement existing travel corridors or special use areas such as thermal cover in adjacent undisturbed areas), and the development of special habitat features on the site (see Section 6.4). Observations of wildlife populations can also be useful in identifying and solving potential wildlife problems.

5.2 HABITAT ASSESSMENT

Habitat-based evaluations of reclamation success are based on the assumption that particular, measurable habitat variables within the site largely determine the suitability of the area for a specific wildlife species or guild. The ability of an area to support wildlife is assessed by:

1. Determining the essential habitat requirements and preferences of the wildlife species or guild of concern;
2. Measuring, or subjectively evaluating, the habitat conditions within a site; and
3. Comparing the existing (or potential) conditions within the site with those conditions considered optimal for the species or guild.

In general, accurate habitat data are less expensive to obtain than accurate population data, easily standardized among sites, not highly-time specific, and not easily influenced by external factors. They also can be applied to different sizes of reclamation sites and, with some methodologies, are easily compared among sites. Deficiencies in habitat quality can also be readily identified by determining the habitat features with the lowest scores. The disadvantage of habitat-based approaches is that they rely on the correct identification and quantification of habitat characteristics that are essential to the use of a site by a species. Because an increasing number of methods are becoming available for assessing habitat quality and habitat models are available for a growing number of wildlife species in the prairie provinces (e.g., IEC Beak 1984 a-f; LGL Limited 1985; Green et al. 1985 b), the latter disadvantage is not a major obstacle to the use of these methods. Because wildlife habitat reclamation requires the manipulation of specific habitat characteristics which can be directly measured by habitat-based assessments and because habitat-based methods are easily adapted to a wide range of conditions for a variety of species, habitat- based assessments are particularly well-suited for evaluating reclamation success.

A variety of techniques have been developed for evaluating habitat characteristics on a site; a review of these methods is outside the objectives of this study and is not considered here. Of the existing techniques, the Habitat Evaluation Procedures (HEP) of the U.S. Fish and Wildlife Service (1980) is perhaps one of the most suitable approaches for assessment of reclamation success, because of its proven success in a wide range of biophysical conditions (e.g., Alaska [USFW [1984a, 1984c], Arizona [Short 1983], Manitoba [Stevens and Storey 1977], Missouri [Basket et al. 1980; Cole and Smith 1983], Northwest Territories [LGL 1985]; Oregon [Matulich et al. 1982]), the good availability of habitat models (see above) and its proven adaptability to reclamation evaluations (Cole and Smith 1983; Matulich et al. 1983, Rhodes 1983). The HEP program was initially utilized in evaluating the effects of water resource developments on wildlife, but has also been used to develop enhancement plans for wildlife (e.g., Matulich et al. 1982). More recently, HEP has been employed successfully as a planning tool for surface mine reclamation activities in Texas (Cole and Smith 1983; Rhodes et al. 1983). While the HEP program is discussed in detail elsewhere (USFWS 1980), a brief overview is provided here.

The HEP approach quantifies habitat suitability as a dimensionless value which incorporates known relationships between specific habitat characteristics and indices of animal abundance or habitat use. A Habitat Suitability Index (HSI), which ranges between 0 and 1, compares site conditions to optimal habitat conditions (0 represents no habitat and 1 represents optimal habitat). An overall habitat suitability index for the site can then be developed, based on an appropriate, arithmetic combination of the individual SI values (calculated for each habitat characteristic) which reflects the relative importance of each habitat characteristic. Because of the linearity of the species/habitat relationships developed in HEP, the magnitude of difference between HSI values generally reflects a similar magnitude of difference between habitat quality. For example, a site with an HSI value of 0.6 should potentially be twice as productive for a given wildlife species as site with an HSI rating of 0.3.

A second important step in HEP, particularly in its application to reclamation sites, is the determination of species- or guild-specific Habitat Units (HU's) for the site. Conversion of HSI values to HU's is achieved through multiplication of the HSI values by the area of available habitat (or size of the reclamation area to be assessed) and serves two functions:

1. It permits the rapid calculation of a value that summarizes the total habitat availability (quality and quantity) on a site which, in turn, provides an easily comparable value between pre-development and post-development conditions (as discussed later in Section 11, we have assumed that habitat assessments will be conducted prior to development and following reclamation); and
2. It enables the habitat loss or gain and corresponding change in wildlife potential as a result of disturbance and reclamation to be determined.

If the reclaimed HU's are insufficient to replace the required number of pre-development HU's, the HEP approach allows the habitat deficiencies to be easily identified through determination of the low scoring habitat features. Application of the HEP program to wildlife habitat reclamation is discussed further below.

5.3 RECOMMENDED METHODOLOGY

5.3.1 Step One: Pre-development Assessment

Prior to disturbance of the proposed development site, baseline surveys should be conducted to determine the types of wildlife present, the use of habitats by wildlife and the distribution of vegetation communities and special features (e.g., cliffs, talus, wetlands, watercourses and licks). Key species for the reclamation plan can then be selected in cooperation with appropriate government agencies (e.g., Fish and Wildlife Divisions). If multiple land uses are planned, reclamation guidelines must be established in cooperation with other government agencies. A baseline habitat assessment, utilizing HEP, should then be conducted to determine the distribution and number of baseline Habitat Units (HU's) for each of the selected key species. These values can be used to determine the objectives for the reclamation program; HU values at the time of the reclamation assessment might be equal to or greater than the pre-development HU's (or a proportion of these HU's if that is deemed appropriate by the regulatory agency).

5.3.2 Step Two: Development of the Reclamation Plan

Because the habitat evaluation models used in HEP assess an area's ability to provide several essential habitat components (e.g., food, reproductive cover, thermal cover) for each key species, these models will help identify specific habitat deficiencies for any given area for a variety of reclamation plans. Consequently, they permit reclamation planners to focus on the most important habitat characteristics for a key species and incorporate these into the reclamation plan.

5.3.3 Step Three: Reclamation Assessment

Once the reclamation area is ready for assessment (this could be determined by measurements of habitat characteristics on a 1-2 year basis), HEP can be used to determine the availability of HU's on the reclamation site. To be certified, a reclamation area would have to provide an equal or greater number of HU's than the accepted objective for the reclamation program. If an area did not provide a sufficient number of HU's, the habitat characteristics that were deficient could be identified using HEP and corrective measures could be implemented.

5.4 TIMING OF THE ASSESSMENT

The period of time required between establishment of a wildlife habitat reclamation area and assessment should allow for sufficient development of the vegetation and stabilization of the terrain to ensure that habitat conditions are suitable for wildlife. Although direct assessments of existing habitat will guarantee that the site provides the necessary habitat conditions for a species or guild, the period of time required for a site to be restored to good or optimal conditions may be in the order of several to many decades depending on the location of the site, climatic conditions, and the intended key species of wildlife. From an economic viewpoint, industrial interests and government agencies may regard this period of time as excessive for bond release.

Because different wildlife species (and guilds) respond differently to habitat characteristics, it is reasonable to believe that the assessment time may differ depending on the key wildlife species. The location of a reclamation site (e.g., eco-region type, elevation, exposure to climatic extremes) may also influence the assessment time.

The optimization of the assessment time from both a biological and economic perspective requires a balance between minimizing the required time period, and ensuring that the habitat is established and will continue to develop normally. Because none of the existing wildlife reclamation areas in the prairie provinces have been established for more than nine years (i.e., the wildlife reclamation area at the Whitewood Mine near Edmonton, Alberta, established in 1976, was the first reclamation area to be developed specifically for wildlife), it is not feasible to utilize existing wildlife reclamation areas to determine an optimal assessment time.

Natural successional patterns and responses of wildlife to these temporal trends may provide some information applicable to reclamation assessments. Bunnell and Eastman (1976) assessed the relationships between successional trends after forest removal and availability of different types of wildlife food (e.g., annual/perennial seeds, herbs, browse, conifer seed and arboreal lichens). Trends were based on a extensive review of the literature and represent an "average" successional example. Production of annual and short-lived perennial seeds was predicted to have the earliest peak (3 to 5 years after clearing), declining to low levels by 18 years after clearing. Herb production also increased rapidly within the first ten years and declined to low levels after 25 years; the rate of the decline is dependent, however, on competition from browse species. Amounts of energy in browse increased gradually, reaching a peak 18 to 22 years after clearing. Peak browse production, however, is highly variable among forest types, locations and reforestation practices (if tree seedlings have been planted). Production of conifer seed and arboreal lichens are dependent on the development of a more mature tree canopy and, consequently, peak production is not realized for a considerable period of time after clearing (e.g., 50 to 300 years). Use of early successional areas by browsing and grazing animals generally parallels these trends in food production (AFWD 1978). In high snowfall areas, however, provision of cover and snow interception may influence or override the physical presence of the food resources.

Of the key species (and associated guild members) that were selected as representative of wildlife guilds in the four biomes, snowshoe hare, mule deer, white-tailed deer, elk and sharp-tailed grouse are the species most strongly associated with early successional communities. All of these groups utilize the herb and browse components of early successional areas to varying extents in their diets. Based on the "idealized" relationships presented by Bunnell and Eastman (1976), it would appear that peak use of successional areas for food resources would occur between 10 and 22 years after clearing. Assuming that vegetation development on reclamation areas will, at best, be equal or slower than on cleared (logged sites), at least the same period of time would be required to ensure that adequate successional habitats are available for wildlife on reclamation sites.

Our present knowledge of vegetation development on reclamation sites is inadequate to determine if assessment times of 10-22 years after reclamation would be appropriate to determine reclamation success for wildlife habitat. We require additional data on growth responses of trees and shrubs in reclamation areas. Such relationships will not only allow us to determine the period of time required to establish stable, high quality wildlife habitat but it may also allow us to develop predictive relationships for tree and shrub growth. These predictive relationships may, in turn, allow us to conduct assessments at an earlier date with a high assurance that the reclamation objectives will be fulfilled.

6.0 WILDLIFE HABITAT RECLAMATION TECHNIQUES[1]

The review of currently-used or proposed reclamation techniques for wildlife was aimed primarily at resource industries which are legally required to reclaim disturbed land. Methods are addressed that are most applicable to the operational conditions of coal mines, oil sands extraction facilities, borrow pits, and linear facilities such as pipelines and roads.

Current practices for many mining and some oil extraction processes necessitate large scale movement of topsoil and overburden to expose the underlying source deposits (Marshall 1983). As a result, the post-mining soils may consist of varying proportions of exposed spoil materials, overburden, and organic topsoil. Although the resulting soil affects the success of revegetation on these sites, methods of reconstructing or enhancing soils are a complex subject beyond the scope of this report and will not be reviewed in this study. In compiling this review, we have assumed that a soil medium has or will be provided on all parts of the reclaimed area where vegetation communities are planned, and that:

1. the soil is suitable for self-sustaining plant growth (i.e., fertilizer applications will not be necessary after an initial establishment period);
2. several species of trees, shrubs and ground covers are capable of surviving in the soil medium; and
3. the soil medium is relatively stable and not prone to significant erosion problems, or subsidence affecting drainage patterns.

In physical habitat types such as cliff faces, talus or waterforms, there may be little or no need for topsoil replacement and stabilization.

We also have assumed that the methods of establishing self-sustaining tree, shrub, and ground covers are adequately defined. The techniques described in this review involve methods of landscape design for wildlife use which encompass the selection of appropriate physical and vegetative features and the juxtaposition of these features to maximize benefits to wildlife.

The following review of reclamation techniques for wildlife habitat examines four major classes of methodologies: topographic modification, watershed re-establishment, revegetation, and special supplementary methods. To encourage an integrated approach to the reclamation of vegetation communities, we have provided some cross referencing among these four major categories of reclamation techniques.

6.1 TOPOGRAPHY AND CONTOURING

Natural landforms generally contain a variety of topographic features that directly or indirectly affect wildlife habitat. Slope steepness, aspect, shape and geological stability are several of the topographic features that influence habitat edge and, consequently, are important in determining habitat diversity and interspersion of vegetation communities (Thomas et al. 1979a; Maser et al. 1979a). Landforms can directly influence wildlife distributions through provision of escape terrain, protective cover from climatic extremes, visual protection, burrow/nest sites, or specialized habitats such as rock talus or highwalls (Thomas et al. 1979a; Tessman 1982; Proctor et al. 1983). Perhaps more importantly from a reclamation perspective, landforms also affect wildlife through their control of the movement of soil and water and the subsequent effects on the rates and success of vegetation re-establishment.

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[1] Portions of this Section have been extracted with modifications from Green et al. (1985a).

During reclamation, materials handling and regrading often result in the loss of most abrupt topographic relief. Reclamation standards in many western provinces and states (see Section 4.0) have required smooth contouring and resloping of overburden and spoil materials. Therefore, reclaimed terrain is often homogeneous with respect to slope steepness and aspect, soil type, soil moisture regimes, and microclimate, offering little visual protection and few special terrain features for wildlife. This loss of topographic diversity also reduces habitat edge and, as a result of the loss of microsite diversity, may hamper the re-establishment of diverse vegetation communities.

In the following section, we examine some of the methods that have been used or proposed to increase or maintain landform diversity in reclaimed areas. Additional information on landform diversity is discussed in Section 6.4 in relation to special habitat features such as rock talus, highwalls and rock piles.

6.1.1 Large-scale Recontouring of Above-ground Features

6.1.1.1 Concept. Modification of material handling methods or recontouring of existing development features have been used to reclaim or enhance surface topography (Tessman 1982; Proctor et al. 1983) and is currently employed or planned in reclamation programs by Cardinal River Coal (G. Acott, pers. comm.), Coal Valley (C. Brinker, pers. comm.), Westar Mining (1983), TransAlta Utilities (P. Lulman, pers. comm.), Parks Canada (G. Harrison, pers. comm.), and Canstar Oil Sands Limited (S. Stephansson, pers. comm.). The creation of rolling surface undulations on reclaimed slopes or flatlands provides a diversity of microsites in terms of exposures to climatic factors, aspect, water/snow accumulation, and soil moisture regimes, which in turn can benefit wildlife through increased topographic variability, vegetation diversity and improved vegetation re-establishment. For example, surface undulations have been used in areas prone to desiccation to improve shrub and herb establishment (Institute for Land Rehabilitation 1978; Sindelar et al. 1973; WECO 1983) and to provide shallow puddles and temporary ponds for birds (Allaire 1979). In areas of relatively flat terrain or on smooth open slopes, surface undulations may help to reduce the line of sight visibility of wildlife (G. Harrison, pers. comm.), and to provide plants with protection from the prevailing winds (G. Acott, pers. comm.). This may be particularly important during the first five to ten years after reclamation when vegetation growth is minimal and is not able to provide adequate hiding cover for wildlife. Surface undulations are not appropriate, however, in areas intended for use as winter foraging areas for ungulates such as bighorn sheep and elk. In these areas, smooth contouring of the slope is necessary to aid in snow removal by wind erosion and sublimation; the lack of snow improves the availability of forage during the winter and promotes an early spring green-up of vegetation. Whenever possible, revegetation should be integrated with the contouring design to maximize habitat diversity (Section 6.3).

6.1.1.2 Techniques. Two methods have been suggested to create major surface undulations within reclamation areas: free-dumping of overburden and recontouring. Since prevailing winter winds in the prairie provinces are from the west to northwest, at least some of the above-grade features should be oriented along north-south to southwest-northeast axes to provide protection from the winter winds.

6.1.1.2.1 Free Dumping of Overburden. Overburden is dumped in a relatively random fashion to create a rough rolling terrain. This technique has been used in flatland areas by Westar Mining (1983) and the Whitewood mine (P. Lulman, pers. comm.) and could also be used to increase surface topography on flat dump tops or wide terraces. Cardinal River Coal and Crowsnest Resources have free dumped overburden along the front slope of dumps to increase topography diversity (G. Acott, pers. comm.; D. Townsend, pers. comm.). Crowsnest Resources has also used free-dumping of overburden to construct large berms (150-200 m long x 20 m wide x 2 m high) at right angles to the prevailing winds to protect tree and shrub seedlings from wind abrasion (D. Townsend, pers. comm.).

6.1.1.2.2 Recontouring. Spoil and overburden piles can be regraded leaving small depressions and hills along the slopes (Allaire 1979; Tessman 1982). Some depressions can be enclosed to create areas for water accumulation, whereas others can be graded to provide broad vegetated waterways that drain downward along gently-graded slopes. Both of these methods should be integrated with watershed re-establishment techniques (Section 6.2). If depressions are created on slopes, particularly steep slopes, care must obviously be taken to control erosion.

6.1.2 Large-scale Recontouring of Below-grade Site Features

6.1.2.1 Concept. Creation of large-scale surface depressions or below-grade features were suggested as a reclamation tool by Tessman (1982) and have been successfully implemented at Cardinal River Coal (G. Acott, pers. comm.) and at a mine site in Montana (WECO 1983). Surface depressions can involve the enhancement of existing depressional features in a development site (e.g., a below-grade haul road) or the excavation of new depressions. The latter method can also be used to create above-ground features with the excavated material. The functions of depressions are similar to those already described for surface undulations; they promote snow/water accumulation, reduce soil erosion, enhance soil moisture, increase surface topography with resultant benefits to vegetation edge and diversity, and provide some hiding cover for wildlife.

6.1.2.2 Techniques. Two approaches have been recommended to create suitable large-scale surface depressions for wildlife:

6.1.2.2.1 Excavation. Tessman (1982) suggested that depressions be excavated with round to elongate designs along shallow slopes or on flat terrain. Although these depressions should be located so as to collect snow melt and runoff water they should not retain standing water. Cardinal River Coal used bulldozers to create trenches across the flat top of an overburden pile that were perpendicular to the prevailing winds (G. Acott, pers. comm.). Development of these features will create conditions that help promote the establishment of shrub communities but will minimize erosion hazards. Recommended specifications include a width of 5-15 m, a length of 10-20 m and depths of at least 1-2 m (Tessman 1982). Care should be taken to locate depressions in areas where overflow will not result in erosion problems. Scrapers may be a more practical alternative to bulldozers or graders in creating depressions (Erickson 1981; cited in Tessman 1982). Surface depressions might also be created using shallow blast charges.

6.1.2.2.2 Enhancement of Landform Features. WECO (1983) undertook the re-establishment of a coulee bottom habitat in an abandoned sub-grade access road. The road was first recontoured to approximate a more natural (sinuous) coulee form. Sites with convergent landscapes and north - northeast aspects were considered the best locations for establishment of vegetation in the new coulee area. In the Mountain, Foothill, Aspen

Parkland and Boreal Forest biomes, haul roads could also be converted to drainage channels (Section 6.2), riparian zones or draws.

Parks Canada has recently completed two wildlife reclamation projects that involved the recontouring of sub-grade or at-grade features -- the Cascade Landfill near the Banff townsite and the Healy borrow pit near the Sunshine Turnoff -- both of which will be reclaimed as elk habitat (G. Harrison, pers. comm.). Regrading at the Cascade Landfill site involved flattening of the landfill and capping with mineral soil and top soil layers, reduction of steep up- and down-slope approaches to the site to permit easier access by animals, and the creation of an artificial draw to provide a visually protected access point into the central region of the reclaimed area. In the case of the draw and several of the regraded slope areas, recontouring complemented existing game trails onto the site.

The Healy pit consists of a 26 ha site that was developed to provide gravel supplies for the twinning project along the Trans Canada Highway and represents one of the best examples of a pre-planned wildlife reclamation project in the prairie provinces. Although the borrow area was originally to have been a standard rectangular design, reclamation planning for the site prior to development enabled Parks Canada to incorporate a seven cell pit design (Figure 2) that is much preferable for wildlife use. Each cell is bowl shaped with gently-sloping grades (i.e., 25%) and is visually separated from adjacent cells by fingers of mature forest and shrubs and gently sloping berms. Sizes of the individual cells and the opening to each cell were determined using the preferred line-of-site distances to elk (see Section 6.3.4.1). Small ponds (0.1-0.3 ha) have also been developed in two of the cells. Slope contouring and placement of the cells complement seasonal movement corridors of elk in this area (G. Harrison, pers. comm.).

6.1.3 Surface Roughening

6.1.3.1 Concept. Surface roughening has been used successfully to improve microsite diversity, penetration of surface water and rainfall, and plant re-establishment on reclamation sites (Sindelar et al. 1973; Institute of Land Rehabilitation 1978; Tessman 1982; Westar Mining 1983). The resulting surface helps to retain surface run-off, reduce wind erosion, avoid soil compaction, entrap sediments and lessen desiccation with subsequent benefits to plant growth. Rough surfaces also provide some shelter for small mammals and some passerine birds.

6.1.3.2 Techniques. Discs, harrows, modified plows and tracked equipment (e.g., bulldozers) can be used to roughen or scarify the land surface (Institute for Land Rehabilitation 1978; Westar Mining1983). Although these methods are generally adaptable to most sites, some specialized equipment has been developed to gouge or dimple the land surface on steep slopes (Sindelar et al. 1973).

6.1.4 Shaping of Overburden and Spoil Material

6.1.4.1 Concept. Kerr (MS, cited in Proctor et al. 1983) described an option for shaping spoil and overburden material to provide topographic diversity in uniformly-shaped or flatland reclamation areas. Coppin and Bradshaw (1982) also suggest special sloping and location of overburden piles to screen wildlife from areas of heavy industrial activity. Because the location of overburden dumps is often dictated by topography and the location of the ore body or resource, specialized shaping and orientation of overbudren piles may not be possible. Where specialized shaping is possible, such large-scale shaping of materials should be incorporated into the pre-mining plan to be economical. Parks Canada has used small berms in the Cascade Landfill near Banff, Alberta to provide visual

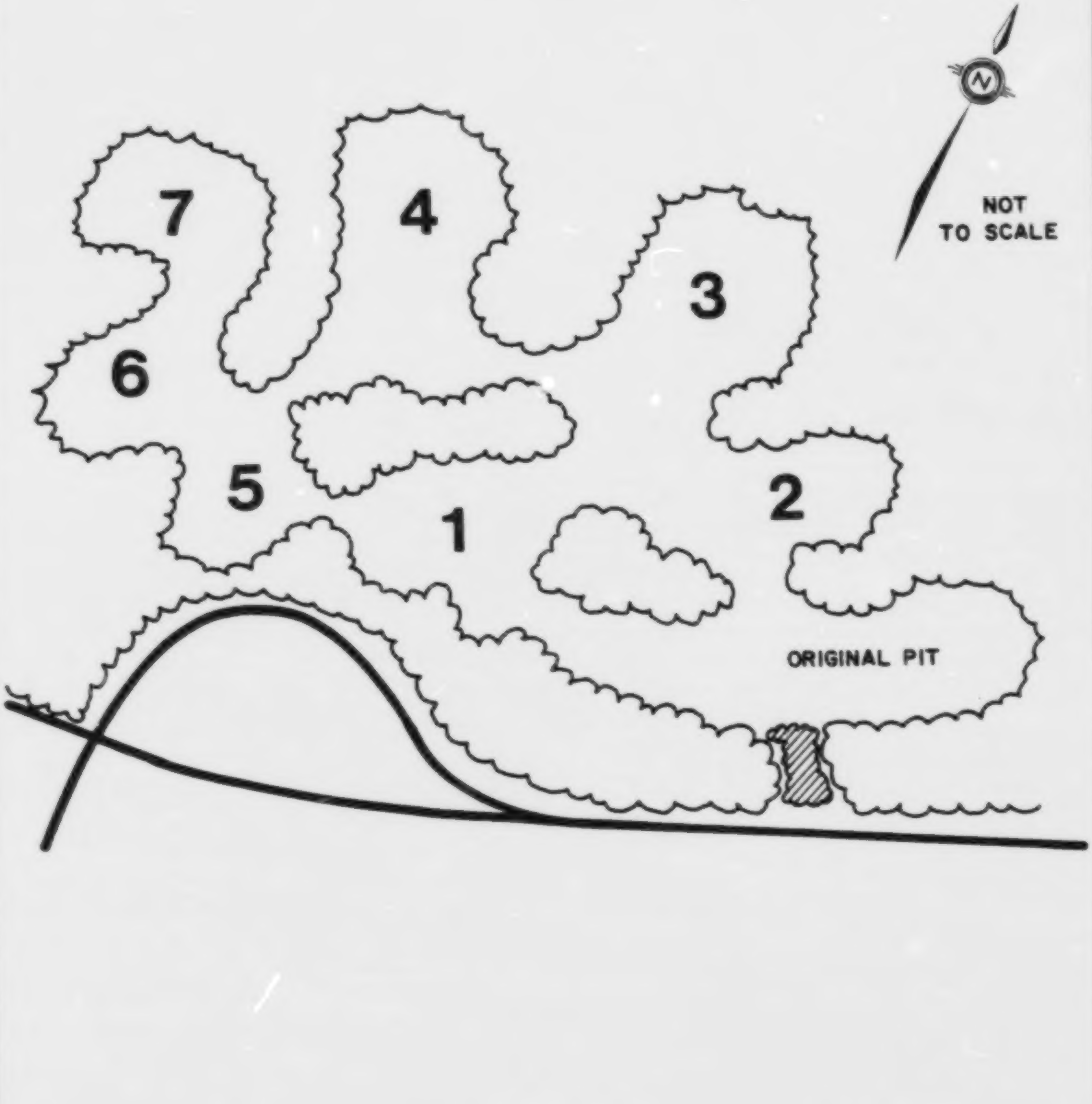
NOT
TO SCALE
N
7
4
3
6
5
1
2
ORIGINAL PIT

Figure 2. Schematic diagram of the seven cell design for the Sunshine Turnoff gravel pit in Banff National Park, Alberta. (Source: G. Harrison, Parks Canada).

protection from a nearby road and to create microsites for shrub establishment (G. Harrison, pers. comm.).

6.1.4.2 Techniques. Kerr (MS; cited in Proctor et al. 1983) suggested that spoil or overburden piles be developed in a crescent-like shape that he referred to as a "poppy seed roll" . The advantage of this form is that it provides a wide variety of aspects, varied air currents and wind exposures, a diverse soil moisture regime, different elevations and varied topography which, in turn, promote plant interspersion and diversity. The revegetation program should then be planned to maximize the benefits of the topographic diversity to wildlife. Parks Canada created a low profile berm in the Cascade Landfill near Banff to provide a line-of-site barrier between animals entering the reclaimed area and an adjacent road. The berm was an extension of an existing rise on the site and complemented an artificial draw that was constructed on the site.

6.1.5 Special Topographic Features

Although special features such as highwalls, rock talus, rock piles and caves will be discussed in more detail later in this report (Section 6.4), they are important supplemental methods of increasing topographic diversity in a reclamation site. Because construction materials and opportunities for creating special features are usually most commonly available during the late pre-development, development and early post-development stages, it is important that plans for special features be implemented early in the pre-planning phase. For example, loose rock/rubble that becomes available during a mine operation can be used to create rock piles, or berms. Similarly, if a highwall was to become available during the mining process, the highwall could be enhanced for wildlife use by developing escape terrain and nesting sites on the highwall and talus areas at the highwall base.

6.2 WATERSHED RE-ESTABLISHMENT

Water is an essential component for the survival of most wildlife. If reclamation areas are to provide adequate habitats for wildlife, it is necessary that self-sustaining water supplies be provided on or in proximity to the reclamation site. Because several of these methods may create or improve fish habitat, piscivorous wildlife and recreational use may also benefit.

An additional benefit of watershed re-establishment for wildlife is the ability of many of the techniques to integrate with and improve watershed protection measures. The rehabilitation of watershed basins, watercourses, waterbodies and riparian zones will help reduce erosion, maintain water quality and improve ground water supplies in the development site as well as improving water quality in areas receiving run-off from the site.

Techniques for the re-establishment of watershed features on a reclamation site are examined below including re-establishment of watercourses, lakes/ponds, wetlands, and riparian zones and the construction of artificial islands. The methods described primarily involve the major physical attributes of watersheds; vegetation features and other special techniques are discussed later in this report (Sections 6.3 and 6.4).

A detailed manual concerning fish and wildlife habitat improvements for reservoirs and streams was developed by Nelson et al. (1978). The handbook describes proven designs for aquatic and riparian enhancement, well beyond the scope of this report and study. The major techniques, applicable to reclamation areas in the prairie provinces, have been incorporated in the following review together with more recent information from other studies.

6.2.1 Watercourse Reconstruction

6.2.1.1 Concept. Drainage structures are designed primarily to transport water away from the development site or to consolidate the water in retaining or sedimentation ponds. Because of design efficiency, these drainage systems are not always attractive to wildlife. However, properly enhanced drainage systems can support dense vegetation cover, provide an easily-accessible source of water and nutritional forage, serve as travel corridors for wildlife, create favourable sites for tree and shrub growth (particularly riparian species), modify the microclimate in the immediate vicinity, and, in some cases, may provide temporary water supplies during periods of low water (Leedy and Franklin 1981; Tessman 1982). Watercourse re-establishment also can promote plant species diversity with obvious benefits to wildlife. Reclamation of watercourses has only recently been implemented in the prairie provinces, with most of the activity being concentrated in the eastern slopes of Alberta (Allen 1985). Gulf Resources has undertaken several stream reclamation projects in the Hanlan- Robb area (Wright 1984), Parks Canada has successfully moved a portion of a stream adjacent to the Trans-Canada highway expansion (Leeson 1984), Coal Valley diverted a portion of the Lovett River (R. Ferster, pers. comm), the Alberta Fish and Wildlife Division in cooperation with Alberta Transportation reconstructed a section of the Crowsnest River (B. Stubbs, pers. comm.) and Petro-Canada implemented some stream bank reclamation measures along several of its pipelines (D. Kohlman, pers. comm.). Fording Coal diverted a section of the Fording River into an abandoned channel, but developed riffles, pools and drop structures to improve summer and overwintering habitat for fish (R. Burdusco, pers. comm.).

6.2.1.2 Techniques. Watercourse reconstruction should involve at least three components: watercourse location and design, watercourse and streambank stabilization, and streambank enhancement.

6.2.1.2.1 Watercourse Design. Although watercourse locations are determined primarily by the post-development topography, routing can be modified within these topographic constraints to improve the value of watercourses to wildlife. It is generally not desirable to completely route surface drainage off the reclaimed site. Drainageways for wildlife should be convoluted to slow the water velocity and to provide a variety of bank heights and shapes resulting from erosional and depositional processes (Nelson et al. 1978; Tessman 1982). Pools can be constructed on bends to provide deeper water areas for fish and some species of wildlife. Bends in the watercourse can be extended, particularly in areas with very gentle slopes, to create oxbow lakes and associated aquatic and riparian communities (Nelson et al. 1978).

Watercourse widths must be adapted to the specific conditions of the site including the drainage area of the watercourse, the resulting discharge volume and the discharge velocity. Bends and loops should occur at intervals of approximately five to seven times the stream width (Wyoming Fish and Game 1976, cited in Tessman 1982). Pools with depths of 0.5-1.5 m below the channel elevation can be constructed by scooping depressions in the major bends of the channel. Ledges can also be used to create scour pools (Allen 1985).

6.2.1.2.2 Streambank Stabilization. Newly-created streambanks are generally prone to erosion and should be stabilized through a combined program of revegetation and erosion control. Keown et al. (1977, cited in Nelson et al. 1978) have comprehensively reviewed most current techniques for streambank stabilization.

In intermittent, gently-sloping channels, reseeding with grasses can reduce stream velocity with subsequent reduction in erosion potential (Nelson et al. 1978; Tessman 1982). Species of grasses, forbs and shrubs that are adapted to hydric conditions should be emphasized in the revegetation of draw bottoms (see Watson et al. 1980). Aquatic vegetation such as cattails and bulrushes can be transplanted in clumps to provide protection for streambanks, but clumps will need to be anchored until root systems are established (Allen 1985). Allen (1985) also recommended the use of transplants of mature trees and shrubs to quickly stabilize streambanks.

Rip-rap, gabions, wood cribbing and various geotextile products (e.g., Curlex™, Enkamat™) can be used to temporarily stabilize streambanks in areas prone to erosion (Nelson et al. 1978; Proctor et al. 1983; Wright 1984). In general, these structures provide only limited cover for fish and tend to locally increase water velocities. Some geotextile products, however, are useful in entrapping sediments and promoting vegetation establishment. Revegetation of banks with riparian trees, shrubs and ground cover should be used with these methods to provide a longterm solution to bank stabilization (Section 6.2.4).

6.2.1.2.3 Bank Cover. Re-establishment of riparian cover is important in increasing both fish and wildlife habitat values along watercourses. Riparian vegetation binds the streambank, offers protection against erosion and provides direct and indirect cover for fish and wildlife (Nelson et al. 1978). Furthermore, because riparian shrub cover can provide shade along a watercourse, it also helps moderate temperature changes in the channel. Well-vegetated streambanks are able to withstand some undercutting, which produces direct cover for fish (Allen 1985) and, to a lesser extent, aquatic and semi-aquatic mammals (e.g., muskrat and mink).

Artificial overhanging streambanks can be reconstructed on the outside bends of stream channels (Figure 3) (Nelson 1978; Wright 1984; Allen 1985). A platform of planks or logs supported on rock rip-rap, gabions or log cribbing (to prevent further back cutting of the bank) can be used to provide an overhanging ledge which, in turn, is covered with a layer of rock and a layer of soil or sod. Vegetation can then be established on the platform using direct seeding or transplanting techniques. Wright (1984) found that revegetation of these banks proceeded rapidly with a good establishment of willows by the end of the third growing season.

In the event that overhanging banks are not required or are not appropriate, a soil cap should be provided on the rip-rap, gabions or wood cribbing. The soil cap will provide a suitable medium for revegetation and, eventually, the restabilization of the bank. In depositional areas along a watercourse (e.g., the inside bank), seeding and transplants of riparian vegetation also can be used to stabilize the watercourse.

6.2.2 Creation of Lakes and Ponds

For the purpose of this review, we have considered lakes and ponds to be those waterbodies which at completion will be moderately to very deep (i.e., average depths greater than 3 m) and consist of a large open water area and a small littoral zone (i.e., less than 20% of the surface area).

6.2.2.1 Concept. During the development of some industrial sites, a variety of waterbodies or potential waterbodies such as sedimentation ponds, end pits, or stockdams are formed. Most of these waterbodies are characterized by steep approaches, sharp banks, few littoral areas, sterile substrates, and restricted water level fluctuations. In some cases,

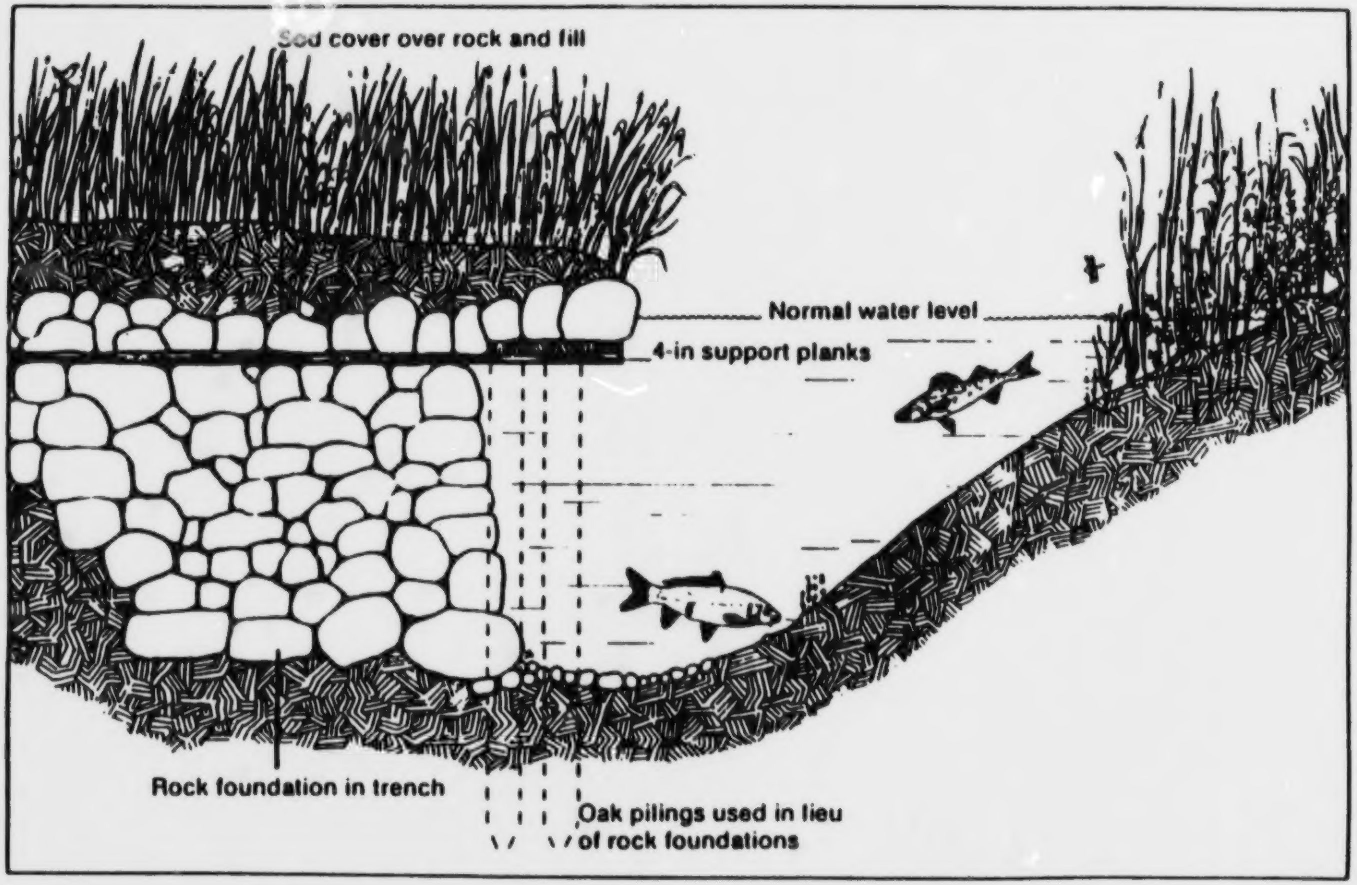
Sod cover over rock and fill
Normal water level
4-in support planks
Rock foundation in trench
Oak pilings used in lieu of rock foundations

Figure 3. Reclamation of overhanging bank habitat in watercourses (Source: Nelson et al. 1978).

water quality may be unsuitable for wildlife because of leachates or waste effluents. Consequently, riparian, emergent, and submergent vegetation is often poorly developed and the resulting waterbodies are of only limited value to wildlife (Olson 1981). However, modification of these waterbodies during construction or reclamation can greatly increase their value to wildlife (Sandusky 1978; Allaire 1979; Olson 1981; Herricks 1982; Klimstra and Thornburg 1981; Szafoni 1982; Tessman 1982; Proctor et al. 1983). In some cases, end pit 'lakes' or impoundments can also be modified for recreational use (Crockett and Beimers 1981). Potential waterbodies within a development site should be enhanced for wildlife only if water quality can be maintained at an acceptable standard.

Large impoundments provide a number of benefits to wildlife: a readily available and permanent source of water; subirrigation of shoreline areas and recharge of the ground water aquifer with subsequent benefits to the establishment of dense, riparian vegetation; potential year-round habitat for fish and hence a potential food source for piscivorous mammals and birds; increased habitat diversity and quality for semi-aquatic mammals, small mammals, waterbirds and amphibians; and improved hunting and roosting areas for some raptors (Tessman 1982). If the primary end use of an area is winter forage for ungulates, a year-round water source should not be provided because it may encourage overuse of these sites during other seasons (Tessman 1982). Modification of impoundments for waterfowl use (see below) should also include the establishment of tall grass meadows and scattered shrubs adjacent to the pond in order to create suitable nesting and brood rearing habitat. Spoil ridges within end pit 'lakes' can also be modified to provide nesting islands (see below) (O'Leary et al. 1984).

No examples of lake creation are known for the Boreal Forest or Aspen Parkland biomes. However, an end pit at the Forestburg Diplomat mine near Red Deer, Alberta (Prairie Grassland biome), has been converted to a 2.5 ha, 7 m deep lake suitable for stocking and overwintering of rainbow trout (B. Logan, pers. comm.). At completion, the final cut was recontoured to 10% slopes, although several steep cuts were left intact. Topsoil was then added to the disturbed slopes surrounding the pond down to a level below the anticipated highwater mark and was reseeded with a forage crop seed mix. Part of this area is now under water. Inflow is primarily runoff from surrounding agricultural land. An overflow outlet was constructed but the lake levels have not yet been sufficient to discharge through this structure. The lake has now reverted to control by the County of Flagstaff. Petro Canada worked in cooperation with Ducks Unlimited to construct a fixed level weir on an intermittent creek in southern Alberta, and thereby created a shallow impoundment along the watercourse (D. Kohlman, pers. comm.).

Within the Mountain and Foothil biomes, a lake has been created at the Cardinal River mine (G. Acott, pers. comm.), and lake enhancement is planned at the Obed (T. Adamson, pers. comm.) and Coal Valley (C. Brinker, pers. comm.) mines.

At the Cardinal River site, one of the end pits will be used to create a 20 ha lake. Although water levels will be deep (>30 m) throughout much of the lake basin, overburden will be backfilled at the pit edge to provide a littoral zone up to 150 m wide and 2 m deep. A shallow berm will also be constructed at the boundary of the littoral and deep water zones to reduce wave action on the shoreline and to maintain thermal variation between the two zones. The littoral area will also be amended with topsoil. The remainder of the pit will provide a deep water area with potential for stocking with rainbow trout. Inflow from several natural streams and outflow along a drainage channel will ensure recharge and flushing. In addition, outflow from the lake will be used to augment water flows during the spawning period for rainbow trout. A combination of macrophyte transplants, plankton inoculations and fertilizer application will be used to stimulate the development of aquatic communities. Tire reefs will be constructed to enhance fish habitat.

At the Obed site, existing borrow pits will be converted for waterfowl use, primarily through construction of shallow littoral zones and nesting islands and transplants of emergent vegetation. Several settling ponds along the west flank of the mine site may also be converted for wildlife use. One of the final cuts at the Coal Valley site may be converted to a 6-7 m deep lake suitable for fish stocking if regulatory approval is obtained (R. Ferster, pers. comm.).

6.2.2.2 Techniques. Site topographic considerations are the first and, perhaps, crucial step in the development of a lake or pond for wildlife and fisheries use (Herricks 1982). Topographic parameters that should be considered include location, depth, size, bank slope, shoreline configuration, bottom contouring, and substrate. Some of these characteristics are illustrated in Figure 4.

6.2.2.2.1 Location. Lakes and ponds within a reclaimed area must be located in stable landforms and compliment the existing or planned topography, the resulting surface hydrology and the remaining portions of the natural drainage basin. Assuming that the primary water source will be surface runoff and snowmelt, the watershed should provide sufficient water to replenish the reservoir annually. It is also preferable to have at least one or more inflow streams and at least one outflow stream for the waterbody in order to maintain water levels and recycle water and nutrients. The watershed plan for the postmine landscape should integrate watercourse reconstruction with waterbody development.

6.2.2.2.2 Substrates. The bottom substrate of a basin must be sufficiently impervious to ensure water retention, prevent saturation of the bank material or spoil, and minimize unstable out-slopes subject to sloughing (Leedy and Franklin 1981). It is generally recommended that a minimum of 20% of the bottom substrate consist of clay or other non-porous materials. Prior to flooding, the bottom substrates of the basin may require compaction to reduce permeability and erosion potential. Highly-porous substrates may necessitate the addition of a bentonite clay substrate as a sealer (Nelson et al. 1978; Leedy and Franklin 1981). Topsoil amendments and hay mulches should be used in any portions of the basin that will have operating depths of 3 m or less. These amendments will provide a suitable growing substrate for emergent plants and will promote the establishment of a natural detrital food chain (Crawford and Rossiter 1982; Haynes 1984). Substrate materials should also have a pH of 5.5 or higher (Leedy and Franklin 1981). More acidic substrates should either be capped with suitable material or limed to increase the pH.

6.2.2.2.3 Depth. At least 25-75% of the basin should have depths greater than 3-5 m and, if possible, greater depths, should be provided (Herricks 1982; Proctor et al. 1983; Rumble et al. 1985) (Figure 4). Deep areas prevent solid freezing of the basin, restrict choking by aquatic vegetation and ensure adequate water during dry periods. To improve bottom diversity (see Bottom Contours below), depths should be variable throughout the basin.

6.2.2.2.4 Bottom Contours. Several aspects of bottom contours are important to wildlife use of waterbodies: topographic diversity, shoreline slope, and littoral zone development. A fourth and related aspect, the development of artificial islands, is discussed later (Section 6.2.5).

Irregular bottom contours provide a high diversity of microsites for fish and invertebrates with resulting benefits to some species of birds and mammals. Herricks (1982) suggests that irregular bottom contours with depth variations of at least 1 to 2 m are preferable for lakes and ponds.

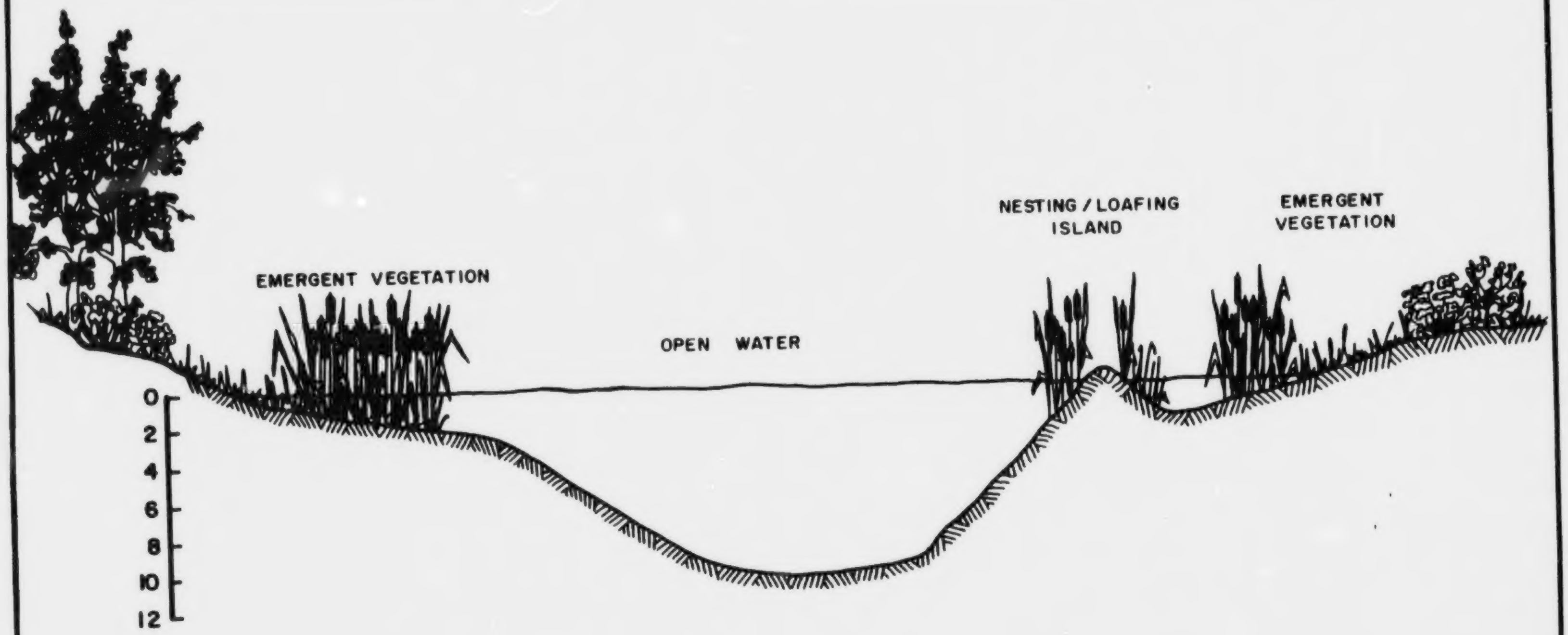
EMERGENT VEGETATION
OPEN WATER
NESTING / LOAFING ISLAND
EMERGENT VEGETATION
0
2
4
6
8
10
12

Figure 4. Preferred cross-section of a reclaimed lake. (A least 60% of the lake should

Shoreline grading should also be variable to increase habitat diversity (Herricks 1982). Slopes of 1:3 to 1:20 appear to be most stable and are preferred in lake/pond reclamation (Nelson et al. 1978; Herricks 1982; Tessman 1982; Proctor et al. 1983; O'Leary et al. 1984). In littoral areas, narrow and wide shelves with gradual slopes (e.g., 1:10 to 1:20) and depths of 0.5 to 1.5 m help promote vegetation development and provide fisheries habitat (Figure 4). Some steep drop-offs also are desirable to provide areas where shoreline access is not restricted by emergent vegetation. Steep bottom contours along at least a portion of the lake or pond shoreline will also provide better habitat for fish as well as access by fishermen to the waterbody (Allaire 1979).

Littoral zones should always be developed as part of the reclaimed waterbody. They are generally the most productive waterbody areas, providing nesting cover for a wide variety of waterbirds and some passerines, protective cover for fish fingerlings and a variety of plant and invertebrate food sources. They also help reduce turbidity, siltation and shoreline erosion (Tessman 1982). Because the extent of emergent vegetation is dependent on the amount of littoral habitat, it is suggested that littoral areas comprise at least 20% of the lake surface area (Herricks 1982). Innoculation of the littoral substrate with bottom ooze from nearby wetlands or lakes would introduce seeds and rhizomes of aquatic plants, and invertebrates. Inclusion of seeds and/or rhizomes of emergent plant species in the soil amendment will also help accelerate the establishment of vegetation cover in the waterbody (O'Leary et al. 1984).

6.2.2.2.5 Shoreline Configuration. Waterbodies created for wildlife use should have irregular shorelines as opposed to simple circular shorelines (Figure 5). Shorelines with numerous peninsulas and bays provide increased edge, littoral areas and depth heterogeneity (Herrick 1982; Proctor et al. 1983; O'Leary et al. 1984) which, in turn, provide the potential for increased habitat diversity and wildlife production.

Highly-convoluted shorelines and associated vegetation communities reduce exposure to wind and wave erosion, provide a good interspersion of feeding and loafing areas for waterbirds and muskrat (Crawford and Rossiter 1982) and create visual barriers between breeding pairs of waterfowl, thereby increasing the potential waterfowl productivity (Tessman 1982).

6.2.3 Creation of Wetlands

For the purpose of this review, wetlands have been considered as small waterbodies with water depths of less than 1.5 m throughout most (80%) of the waterbody basin. Assuming that bottom substrates and water quality are suitable for plant growth, most of the wetland should be capable of supporting emergent plant growth.

6.2.3.1 Concept. Shallow basins within a mine drainage system, borrow pits, sedimentation ponds for watershed protection or sewage treatment lagoons offer opportunities to develop wetland areas. Wetlands can provide many of the benefits already described for lakes/ponds -- provision of a water source, subirrigation of adjacent land, recharge of the groundwater aquifer, increased habitat edge, and increased potential for development of riparian zones -- as well as the provision of a potentially valuable habitat for waterfowl, shorebirds, some passerines, aquatic mammals (particularly muskrats) and amphibians and the potential for treatment of some water pollutants and sedimentation (Kadlec 1981; Alberta Energy and Natural Resources 1985b).

Wetland basins have been created in several wildlife reclamation projects in the prairie provinces, primarily in conjunction with reclamation of borrow pits. Alberta Energy and Natural Resources (1985b) has recently released a Habitat Development Fact Sheet

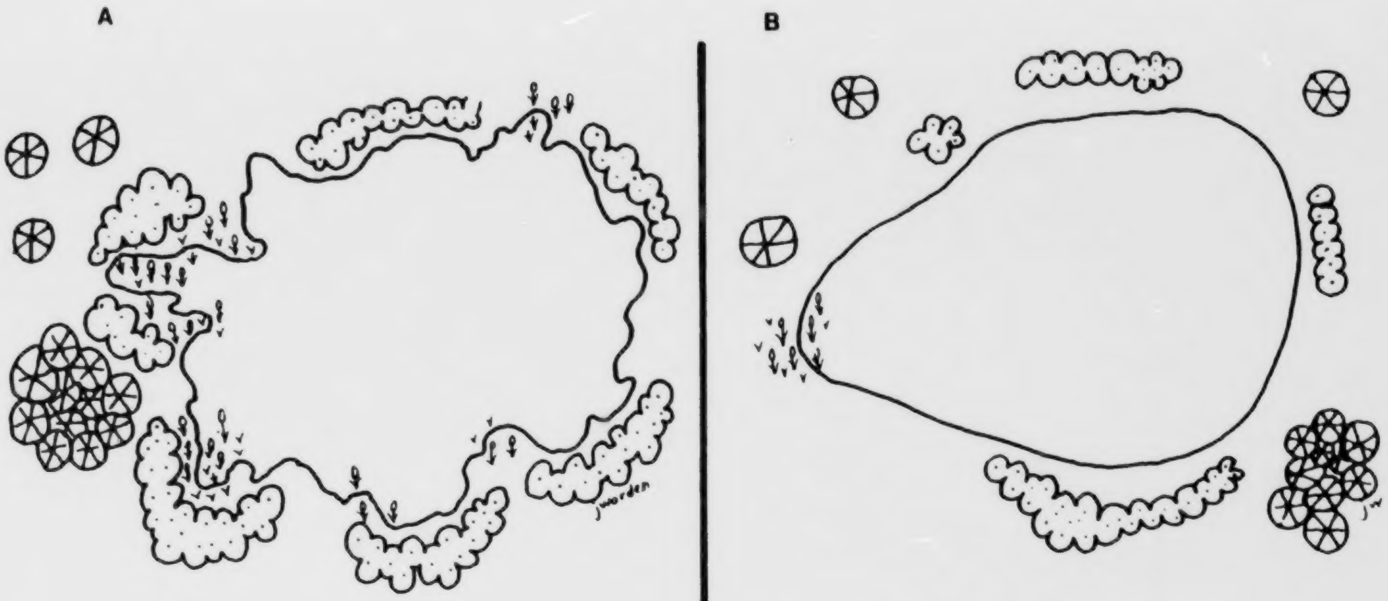

Figure 5. Wetland shape and shoreline complexity. (Wetland A is an example of a wetland with high shoreline complexity and is preferred over Wetland B for wildlife habitat enhancement. Irrregular shorelines increase the amount of terrestrial and aquatic edge and, in turn, provide increased ecotone habitats for wildlife.) (Source: Szafoni 1982).

which provides general instructions for enhancing borrow pits for waterfowl. In Banff National Park, Parks Canada incorporated several small wetland ponds (0.1-0.3 ha) into the design of a multi-celled 26 ha borrow pit. All of the ponds were created by excavation below the existing water table. Home Oil created a small pond in the Manyberries region of Alberta by constructing a low berm across a small depression along an intermittent watercourse (D. Mutrie, pers. comm.). Petro-Canada worked cooperatively with Ducks Unlimited in the Drumheller region of Alberta to develop several wetlands for waterfowl in borrow pits for the Connorsville Gas Production Scheme (D. Kohlman, pers. comm.). In the latter example, the borrow pits were deliberately located to intersect intermittent streams and so ensure a relatively reliable supply of water. Recontouring of the pits was required following extraction in order to maximize the abundance of shallow water areas (i.e., less than 1 m). Wetland basins also have been created as part of a wildlife enhancement program at the Widco site in southeastern Washington State (Clausing 1981). Borrow pits were converted to wetlands and a disturbed creek bottom area was rehabilitated as riparian habitat with small wetlands. The Decker mine in southeastern Montana developed a 15 ha marsh adjacent to the Tongue River reservoir using spoil materials from the mine for construction of dikes. In addition, mine waste water was used for the majority of the annual water requirements of the marsh (Gregory et al. 1984). Settling ponds at the Obed mine site may be converted to wetlands (T. Adamson, pers. comm.) and saline retention ponds at the Montgomery mine site may eventually be enhanced for use by shorebirds and waterfowl (K. Natsukoshi, pers. comm.).

Although revegetation of wetlands are not discussed in detail here, it is important that some grassland habitat and lesser amounts of shrubland habitat be established near the wetland. The grassland and shrubland areas together provide important nesting sites for waterfowl which, in turn, will promote waterfowl productivity. Alberta Energy and Natural Resources (1985b) provide general planting recommendations for wetlands as well as suitable species for dry, moist and saturated sites. If livestock will be present on the site, livestock access to the wetland should be restricted by fencing a narrow corridor to the pond edge. This will prevent excessive trampling of the vegetation along most of the shoreline of the pond.

6.2.3.2 Techniques. Design specifications for reclaimed wetlands include substrate, area, depth, bottom contours, shoreline configuration and littoral zone development.

6.2.3.2.1 Substrate. Substrate requirements for wetlands are almost identical to those already described for lakes/ponds, with the exception that most of the bottom substrates should be suitable for plant growth (see Section 6.2.2.2.2).

6.2.3.2.2 Size. Wetlands size can generally be adapted to the needs of the mine plan. Proctor et al. (1983) suggest, however, that wetlands be 0.2 to 4.0 ha in size with wetlands in the 0.4 to 2.0 ha range being optimal for waterfowl production. Wetlands smaller than 0.1 ha are of little use to wildlife and should be consolidated to form larger wetland areas.

6.2.3.2.3 Depth. The extent of shallow (0.5 - 1.5 m) water areas is probably the most important determinant of wetland suitability for wildlife. The amount of shallow water largely determines the amount of emergent aquatic vegetation and, in turn, significantly influences the use of wetlands by wildlife such as waterbirds and aquatic mammals. However, because very dense stands of aquatic vegetation can inhibit wildlife use, the hemi-marsh -- a wetland complex with a 50:50 composition of vegetation and open water areas -- appears to be most productive for wildlife (Weller and Fredrickson 1974). Depths should therefore be variable with 30-75% of the basin occupied by shallow water areas no more than 1.5 m in depth (Rumble et al. 1984).

6.2.3.2.4 Bottom Contours. Uneven bottom contours are preferred for reclaimed wetlands (Crawford and Rossiter 1982; Herricks 1982; Proctor et al. 1983). Irregular contours provide a variety of water depths and microsites and allow for a good interspersion of emergent vegetation and open water. If the pre-flooding basin is smoothly contoured, the topographic diversity of the bottom substrate could be increased by excavating deeper pools and constructing shallow platforms with the excavated material.

Shoreline slopes should be variable to increase the interspersion of littoral and deep water zones. Slopes in littoral areas should be 5-10% (Crawford and Rossiter 1982; Herricks 1982) whereas slopes in deep water areas can be as steep as 30% if the substrate material is stable. Bottom contouring in wetlands should also consider the construction of artificial islands for wildlife use (Section 6.2.5).

6.2.3.2.5 Shoreline Configuration. As described for lake/ponds, wetland shorelines should be convoluted to promote wildlife use (see Section 6.2.2.2.5).

6.2.4 Riparian Zones

6.2.4.1 Concept. Riparian zones generally support a greater number and diversity of wildlife and sustain higher levels of productivity than most other terrestrial or aquatic habitats (Odum 1971; Thomas et al. 1979b). They also have a significant influence on the physical, chemical and biological properties of the associated terrestrial and aquatic communities (Szafoni 1982). Riparian vegetation helps slow overland drainage, increases percolation, reduces sheet erosion, stabilizes streambanks and helps to trap sediments and nutrients (Szafoni 1982). Riparian areas are not only beneficial to wildlife but also provide some watershed protection.

Moist to wet areas and seeps frequently develop as part of the drainage system within a mine site and, because water is readily available, trees and shrubs establish easily in these areas. Subsurface irrigation in the areas around wetlands, lakes and ponds also offers excellent opportunities for reclamation of riparian habitats. Riparian development has been incorporated into reclamation plans for the Cardinal River mine (G. Acott, pers.comm.), Gregg River mine (Hardy Associates 1982; M. Murphy, pers. comm.), the proposed McLeod River project (McLeod River Coal Ltd. 1982), the Suncor Inc. Oil Sands operation (T. Shopiks pers. comm.) and the Widco Site in Washington (Clausing 1981) and is presently being implemented at the Westmoreland mine in Montana (Westmoreland 1984).

6.2.4.2 Techniques. Riparian areas should be developed in moist to wet areas that result from mine drainage and waterbody/watercourse creation and enhancement. Areas that remain moist throughout most of the growing season are most preferable. Revegetation in riparian areas should include an interspersion of trees, shrubs and ground cover adapted to mesic and hydric conditions (see Sections 6.3.3.3 and 6.3.3.4).

6.2.5 Island Development

6.2.5.1 Concept. Small islands in lakes, ponds and wetlands can provide additional terrestrial - aquatic edge and littoral areas while also providing an aesthetic landscape element in the waterbody. They are also an effective method of improving waterfowl nesting success because of reductions in terrestrial mammal predation (Stoecker 1982). Development of islands in conjunction with mud flats and shoals can also improve feeding and loafing areas for some waterbirds (Stoecker 1982; O'Leary et al. 1984). Islands can often be easily created during the construction of ponds, lakes and wetlands, particularly if recontouring or resloping of the basin is required. Alberta Energy and Natural Resources

(1985a) have released a habitat development fact sheet specifically for the development of nesting islands for waterfowl.

6.2.5.2 Techniques. Artificial islands have frequently been constructed as part of marsh enhancement programs (e.g., Ducks Unlimited projects) and can easily be incorporated into the site reclamation plans for most waterbodies. Front-end loaders and bulldozers have been used effectively to construct artificial islands prior to flooding (Nelson et al. 1978; Stoecker 1982; Proctor et al. 1983). Spoil pile tips in end pit 'lakes' also can be easily adopted as nesting islands for waterfowl (Haynes 1984; Klimstra and Thornburg 1982). A gravel nesting island was included in the wildlife reclamation plan for the recently completed Healy borrow pit in Banff National Park (G. Harrison, pers. comm.). Cardinal River Coal may include artificial islands in their pit-lake reclamation program (G. Acott, pers. comm.). Specifications for construction of artificial islands include location, size, substrate, elevation and shape.

6.2.5.2.1 Location. Waterfowl nesting/loafing islands should be separated from the mainland by water at least 9.0 m wide and 0.5-0.6 m deep (Keith 1966). Where several islands are to be constructed in a waterbody, they should be well dispersed (i.e., 100-150 m apart) to reduce territorial strife during the breeding and nesting periods. Alberta Energy and Natural Resources recommend that numbers of islands not exceed one per 20 ha of wetland.

Shelter from prevailing winds is an important consideration in reducing wave erosion of the island and encouraging wildlife use (Stoecker 1982; Alberta Energy and Natural Resources 1985a). Preferred locations include the upwind side of the waterbody, coves, and protected areas behind larger peninsulas. Locations within large stands of emergent vegetation will also reduce wind and wave erosion. Tree and shrub plantings on the mainland, upwind from the island, can also be used to protect the island.

6.2.5.2.2 Size. Island sizes of 1 to 200 m^2 or larger have been employed successfully in a number of lake/marsh enhancement programs (Hammond and Mann 1956; Nelson et al. 1978; Giroux 1981; Stoecker 1982; Proctor et al. 1983). Size does not appear to be a critical factor in wildlife use of islands. In large waterbodies, several well-spaced smaller islands are preferable to one large island. Alberta Energy and Natural Resources (1985a) suggests that nesting islands should provide a total area of approximately 500 m^2 whereas nesting mounds should be a minimum of 95 m^2.

6.2.5.2.3 Substrate. Islands may be constructed of overburden, rock or any other relatively stable fill material. Where wave action may erode the structure, rock rip-rap, gabions, wood cribbing and geotextile fabrics can be used for short-term stabilization. Because vegetation enhances the value of islands to wildlife, the island should be capped with top soil to provide a suitable substrate for plant growth (Stoecker 1982; Proctor et al. 1983). Straw mulch can also be applied as a short-term stabilizing cover. Vegetation established on the island should be appropriate for its size and intended use. On small islands or islands intended primarily for waterfowl use, plantings of grasses, forbs and emergent aquatic plants are preferred. On larger islands, areas of riparian shrubs and trees can be established to increase habitat diversity, to stabilize the island banks and to provide some protection from wind exposure.

6.2.5.2.4 Elevation. The tops of artificial islands should be at least 1 m above the high water mark to avoid nest destruction during flooding or severe wave action (Proctor et al. 1983).

6.2.5.2.5 Shape. Shape is not an important design criterion for small islands but becomes increasingly more important as the island size increases. On larger islands, irregular shorelines provide the best wildlife habitat (see Section 6.2.2.2.5). Small peninsulas and bays offer protected areas for waterfowl feeding and loafing whereas crescent shaped islands, oriented away from the prevailing winds, provide larger protected areas (Stoecker 1982). Mud bars, shoals, exposed cobble areas and snags can also be incorporated into the island design (Figure 6) to provide additional habitat diversity for some species of birds and mammals (Stoecker 1982; O'Leary et al. 1984). Long narrow islands should be oriented parallel to the prevailing winds to reduce wave erosion and wind exposure (Alberta Energy and Natural Resources 1985a).

6.3 REVEGETATION

Following development of post-production topography and watershed re-establishment, revegetation is the final and essential element in successful reclamation. Although reseeding of reclaimed areas with domesticated species of grasses and legumes has been a common practise for several decades, few attempts had been made to reclaim vegetation communities on disturbed areas. Consequently, our knowledge of community reclamation and plant community dynamics on reclaimed land is minimal. Reclamation research to address community development is presently underway at Cardinal River Coal (G. Acott, pers. comm.), Coal Valley (R. Ferster, pers. comm.), Westar Mining (1983), Whitewood mine (P. Lulman, pers.comm.), Suncor Oil Limited (T. Shopik, pers. comm.), and Parks Canada (G. Harrison, pers. comm.).

The revegetation component of wildlife habitat reclamation must consider a wide variety of factors including the availability of seed and rootstock, seasonal habitat requirements of wildlife, size of the reclamation area, geoclimatic constraints, the selection of palatable and unpalatable plant species appropriate for the probable microsite conditions, successional patterns within the re-established communities, spatial arrangement of plants within the communities and spatial arrangements of community blocks.

6.3.1 Revegetation For Key Species

The main function of the revegetation plan, from a wildlife habitat perspective, is the integration of proposed vegetation communities with physical features of the site to fulfill the needs of the selected key species. Vegetation communities provide the essential elements of food and/or cover for most wildlife and can provide or enhance access to the other essential element, water. Cover requirements can include thermal cover, reproductive cover, and/or hiding and escape cover.

The success of the revegetation program in re-establishing wildlife habitat is dependent on the recognition of the physical constraints of the post-development topography, soils and hydrology on plant community development. In developing a conceptual approach for revegetation of wildlife habitat we are faced with the reality that different plant communities are adapted to different biophysical conditions. Regardless of the perceived requirements of a key species for a particular habitat, we cannot provide that habitat unless the basic requirements of soil fertility, moisture, aspect, slope and exposure are present. For example, if no moderate to steeply sloping, southern to western aspects with high wind exposures are available in a reclamation site, it is unlikely that some types of winter foraging areas for elk and deer can be successfully created.

The spatial requirements of wildlife species in relation to the size of the reclamation area places additional constraints on a revegetation program. Each species

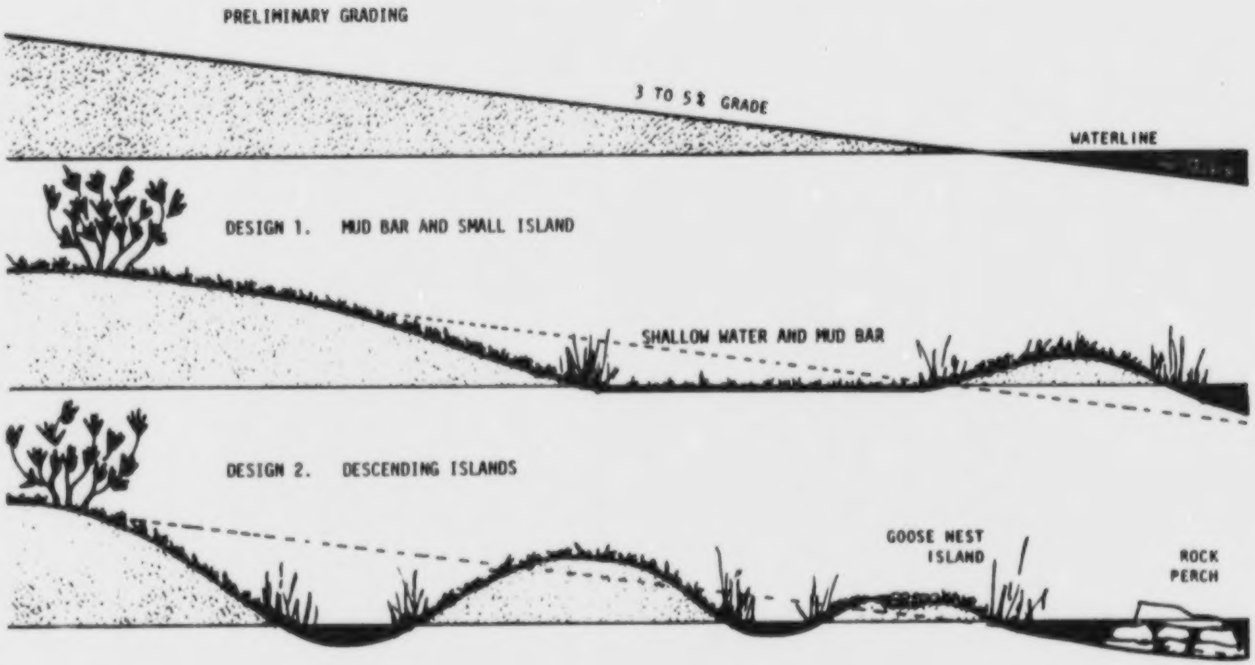
PRELIMINARY GRADING
3 TO 5% GRADE
WATERLINE
DESIGN 1. MUD BAR AND SMALL ISLAND
SHALLOW WATER AND MUD BAR
DESIGN 2. DESCENDING ISLANDS
GOOSE NEST ISLAND
ROCK PERCH

Figure 6. Construction of artificial islands. Recontouring of the shoreline slope can increase habitat diversity through creation of islands, mud bars, shoals and littoral zones.) (Source: Stoecker 1982).

exploits several habitat types during its lifetime to obtain an acceptable balance of food, cover, and water, and it may not be possible or desirable to provide all of these requirements in a single reclamation area. The size of a reclamation area, in relation to the spatial requirements of a key species, obviously will influence the number and types of habitats and special habitat features that can be provided. However, space requirements for most wildlife species are poorly understood. In particular, little information on the spatial requirements of the key species in relation to specific life and seasonal phases is available that is specific to any biomes in the prairie provinces.

The existing successional states of many of the major habitat ecoregions in the Aspen Parkland, Boreal Forest, Mountain, and Foothill biomes reflect a history of fire suppression. Seral habitats are less abundant today than in the past whereas mature, later-successional habitats are abundant. Most reclamation sites in these biomes remove areas of homogeneous mature forest cover that are small in relation to the regional abundance of these forest communities. In many cases, forest communities adjacent to reclamation sites will provide ample thermal cover and, possibly, hiding cover for wildlife (Wallis and Wershler 1979; Millson and Bondy 1984). Therefore, it would seem most beneficial to wildlife if habitat reclamation focused initially on the provision of food, reproductive cover and hiding cover (to promote use of the new food sources). Although some provisions may be made to re-establish thermal cover over the longterm, the length of time required to restore thermal cover (e.g., 70 to 130 years or more) (Thomas et al. 1979c), precludes its consideration in programs aimed at restoring early successional communities. Thermal cover also could be provided by minimizing the clearing of mature forest cover on a development site. Maintenance of these uncleared 'islands' would also provide some food and cover for wildlife and a seed source for natural revegetation.

6.3.2 Selection of Species

The relationship between vegetation communities, their species composition and utilization of these species by wildlife is complex and not well understood, yet plant species selection is an essential element in the rehabilitation of land for wildlife habitat. Animal preferences for plant species do not follow common methods of vegetation classification. Wildlife may use one group of plant species for food and another group of species for hiding or thermal cover; additional plant species may be important components of reproductive cover, or may provide a suitable source of moisture. Use of these vegetation groups also may be influenced by season or factors such as natural predators, inter- and intraspecific competition and harassment by humans.

In the following discussion, we examine several factors that will influence the choice of revegetation species for wildlife habitat: key species requirements, forage quality, palatability and revegetation potential.

6.3.2.1 Key Species Requirements. Trees, shrubs and/or ground cover must be selected to satisfy the seasonal requirements of the key species for food and cover. Dietary analyses of bighorn sheep and elk have been used to select plant species for use in the reclamation program at Crowsnest Resources (B. Densmore, pers. comm.). Plant species that are commonly consumed by elk and bighorn sheep will be included in the seed mix (if seed is available) as well as 3-4 species of plants known to survive well on the site. Reviews of the major dietary requirements of several large herbivorous mammals were compiled to provide lists of plant species for potential use in the reclamation program at the Cardinal River (Wallis and Wersher 1979) and Fording Coal (Norecol 1984) mine sites. Important food and cover species are summarized for the key species in each biome (Sections 7-9). Wildlife use and palatability of grasses, forbs, shrubs and trees of known commercial propagation are also summarized in each biome.

6.3.2.2 Forage Quality. Quality of forage should also be considered in species selection. Considerable controversy has arisen over the use of native species as opposed to commercial species in revegetation (see Sims et al. 1984 for a review). Native species are often suggested as preferred species for wildlife habitat reclamation because they are adapted to local conditions and are utilized by wildlife in natural areas. There is insufficient evidence, however, to suggest that introduced or agronomic species are inferior or superior to native species in terms of adaptability, wildlife preference, nutritional value and productivity (Institute of Land Rehabilitation 1978; Sims et al. 1984).

Several studies in the western United States have shown that although introduced species may be more productive than native species for several years after seeding, productivity of native species increases after the first few years and may exceed that of introduced species (see Sims et al. 1984 for a review). Mitchell (1973, cited in Sims et al. 1984) suggested that native grasses sacrifice seed production for vegetative growth and propagation during the initial establishment period. Once established, however, these native species require little maintenance as a result of their adaptations to the biogeoclimatic conditions and, hence, in the long term, are preferred to introduced species.

Until further research is conducted to determine if native or introduced species are preferable for reclamation of wildlife habitat, it is not possible to recommend selection of either group at the expense of the other. Moore et al. (1977; cited in Sims et al. 1984) suggest that plant species selection should focus on the successional status of the species rather than its genetic source. For the present time, species should be selected that are preferred by wildlife but that also can be grown with moderate to high success within the conditions of the reclamation site. The availability of seed and rootstock will also limit the choice of species (see below).

Wildlife habitat should not necessarily be equated with the production of forage (Scotter 1980). The question of "the relative importance of forage-related compared with structure-related habitat features as predictors of habitat use" needs to be answered. Also "...research should be concerned not only with the quality and quantity of habitat but also with whether habitat can and will be used" (Scotter 1980:24).

6.3.2.3 Palatability. Forage palatability may be a valuable tool for managing artificially created wildlife habitat. Plants with low palatability could be seeded on areas sensitive to overuse (e.g., a high erosion hazard), or critical to other wildlife such as ground-nesting birds. Seasonal differences in palatability of plants raises the possibility of avoiding overuse of winter forage supplies early in the season. However, the effects of palatability on reclamation for wildlife are not well understood and further research is required.

Research on wildlife preferences for commercially available species is almost non-existent. Smith et al. (1979) found that captive elk fed dried grass forage appeared able to distinguish between closely related species. For example, intake rate was different for creeping red fescue and chewings red fescue, and for bearded wheatgrass, streambank wheatgrass and northern wheatgrass. Creeping red fescue and smooth bromegrass were preferred species at the mid-season phenological stage. Streambank wheatgrass initially was shunned by the elk but later was consumed quite rapidly suggesting an acquired taste (USDA 1972).

Plant palatability in free-ranging situations is difficult to assess. Palatability rankings based on levels of utilization may reflect actual palatability as well as plant availability. In cases where palatable species are overgrazed or uncommon, less palatable and more commonly-occurring species may be utilized more than the palatable species.

The nutritional value of these less palatable species may exceed the nutritional value of the palatable species under some range conditions (M. Ross, pers. comm.)

Observations of ungulate use of ground covers commonly seeded on reclamation sites in British Columbia and Alberta suggest that growing conditions and fertilization on reclaimed sites may alter the palatability of many plant species for wildlife. Elk will preferentially consume some species but will eat almost any of the species planted on a site (G. Harrison, pers. comm.; D. Lane, pers. comm.; D. Walker, pers. comm.). Bighorn sheep have also been observed not to be highly selective of ground cover species on reclaimed sites (G. Acott, pers. comm.).

6.3.2.4 Reclamation Potential. Selected species must, of course, be available as seed or for other methods of propagation and be viable under the reclamation conditions. Watson et al. (1980) reviewed the suitability of grasses, forbs, shrubs and trees for reclamation in Alberta; information is provided on the ecological requirements, soil preferences, palatability to domestic animals and wildlife, seed availability, methods and ease of establishment and current status for reclamation. Information from this review and several other sources has been tabularized for each biome to illustrate potential uses for wildlife reclamation (Sections 7-9).

6.3.3 Plant Community Reclamation. In Sections 7-10, we briefly describe the major ecoregions of the Aspen Parkland, Boreal Forest, Mountain and Foothill biomes and the successional trends and wildlife communities of these ecoregions. As a result of propagation problems and implementation costs, we may not always be able to utilize all of the plant species that we require to meet the needs of the key wildlife species or to restore the various habitat strata for community development. Despite these difficulties in plant and seed supply, revegetation for wildlife habitat should still attempt to develop plant communities as opposed to monotypic or homogeneous block plantings, in order that successional processes are encouraged as much as possible.

In the following section, we briefly discuss the types of plant communities that can be developed in wildlife habitat reclamation and the distribution of plant communities in the reclamation site. Information on community location and structure was derived from McLeod River Coal Ltd. (1982), Hardy Associates (1982), Westar Mining (1983), WECO (1984), Westmoreland Resources (1984) and Suncor Inc. (T. Shopik, pers. comm.). Potential locations of plant communities in relation to specific physical features within two different types of reclamation sites are illustrated in Figures 7 and 8. Specific revegetation techniques for wildlife habitat are considered in Section 6.3.4; additional information on revegetation methods and selection of plant species are described for each biome in Sections 7-9.

6.3.3.1 Grasslands. Reclaimed grassland communities might include an upland grass community, a lowland grass community and a riparian or sedge-dominated grassland. Although these communities should consist primarily of grasses and sedges, legumes such as alfalfa, clovers and milkvetch can augment forage production, palatability, and overall vigor of the community.

Upland grass communities are best developed on xeric sites with a high degree of exposure to wind and sun. Planting mixes should include a mixture of predominantly warm season grasses such as bromegrass, Russian wild rye and creeping red fescue (Westar Mining 1983). Upland grass communities are an important component of elk and deer winter range as well as a year-round forage source for bighorn sheep and mountain goats.

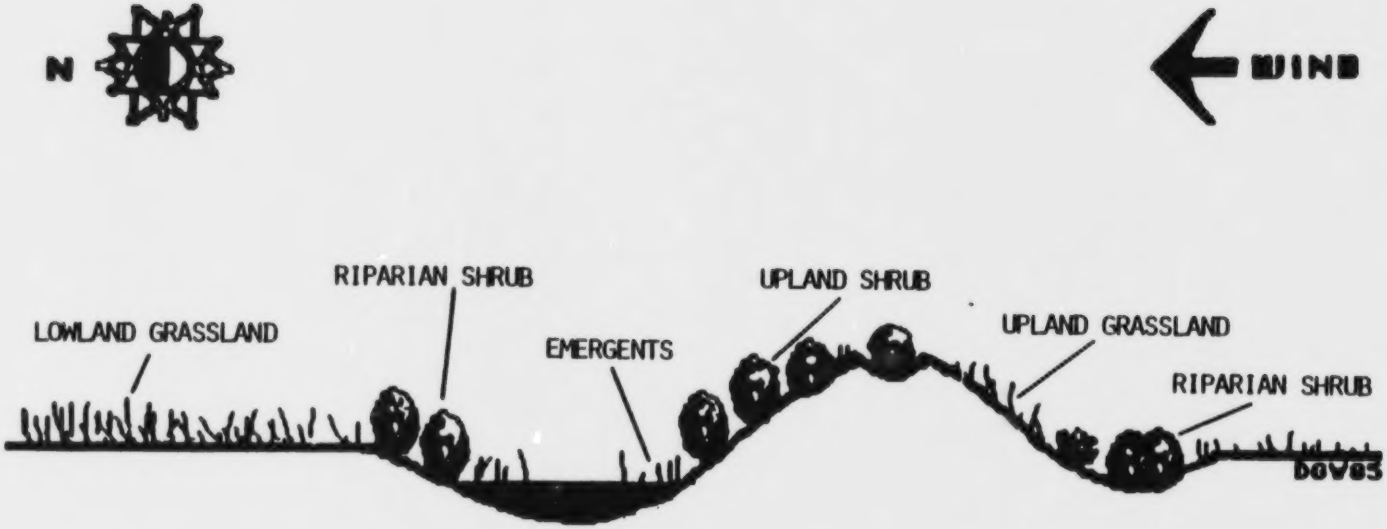
N
WIND
RIPARIAN SHRUB
LOWLAND GRASSLAND
EMERGENTS
UPLAND SHRUB
UPLAND GRASSLAND
RIPARIAN SHRUB
DOV83

Figure 8. Potential locations for plant community establishment on flat terrain within a reclamation site.

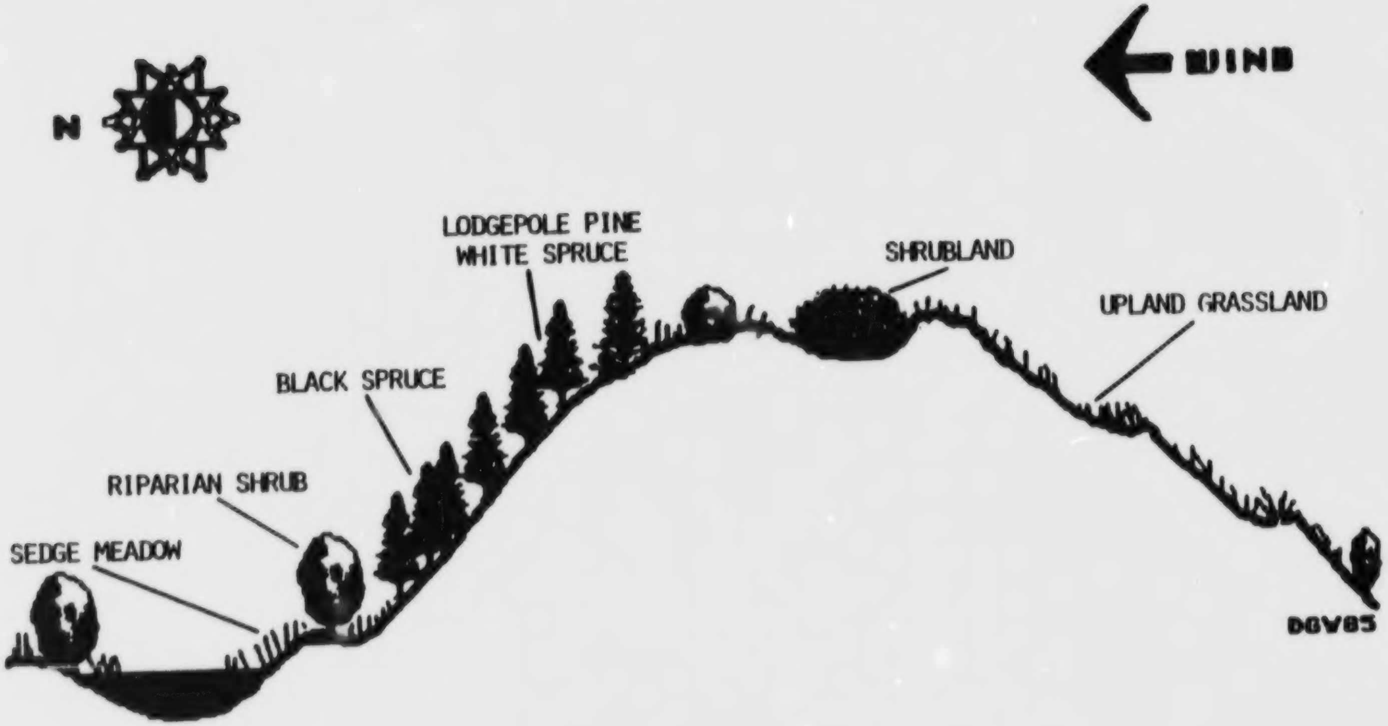
N
WIND
LODGEPOLE PINE
WHITE SPRUCE
SHRUBLAND
UPLAND GRASSLAND
BLACK SPRUCE
RIPARIAN SHRUB
SEDGE MEADOW
DGV83

Figure 7. Potential locations for plant community establishment on an overburden storage area.

Lowland grass communities can be established on flat to gently-sloping areas (i.e., mid- and lower slopes) with eastern, southern or western exposures. Cool season grasses such as Kentucky bluegrass, Canada bluegrass, timothy, and slender wheatgrass should preferably dominate the seed mix. Lowland grass communities would provide nesting cover for waterfowl and passerines, spring-fall foraging areas for ungulates, and habitat for some small mammals.

Riparian or sedge-dominated grasslands can be established on poorly drained areas at the base of slopes, in moist depressions or adjacent to reclaimed wetlands and watercourses. Sedges, graminoids (e.g., creeping red fescue, reed canarygrass, tall wheatgrass, meadow foxtail and timothy) and forbs adapted to hydric and mesic conditions should dominate the seed mix. Riparian grasslands would provide nesting cover for waterfowl and passerines and excellent cover and food for small mammals.

6.3.3.2 Emergent Aquatics. Emergent aquatic communities can be developed in association with permanent or semi-permanent wetlands or other waterbodies. Possible species include bulrushes, cattails, reed grasses, sedges, water lilies, arrowhead and submergent or floating vegetation such as duckweed and pondweed. Transfers of bottom ooze and rootstocks from adjacent natural wetlands can be employed to accelerate establishment of emergent vegetation (Crawford and Rossiter 1982). Emergent communities provide a food source for muskrat, beaver and some waterbirds, nesting sites and materials for waterfowl and some passerines and construction materials for muskrat.

6.3.3.3 Shrub Meadows. Shrub meadows can be established in association with lowland grass communities or riparian grassland communities. To maintain a relatively open community, mature shrubs should not occupy more than 25 percent of the habitat unit area. Potential species include willow, alder and dwarf birch. Shrub meadows are best established in close association with waterbodies and wetlands in order to provide nesting cover for waterbirds and passerines. They can also be used as an ecotone between dense shrublands and grasslands.

6.3.3.4 Shrublands. Shrubland communities can include upland and riparian shrublands.

Riparian shrubland can be developed in a variety of mesic situations along waterbodies and watercourses, and in moist depressional sites and valley bottoms. Tall willow, dwarf birch and, possibly, alder, high-bush cranberry, low-bush cranberry, and red-osier dogwood, should dominate the plantings. Balsam poplar could also be incorporated to eventually provide a tree stratum along watercourses. Riparian shrublands can provide cover and browse for most ungulates and white-tailed ptarmigan, a food source and construction materials for beaver, and nesting sites for passerines and some waterbirds.

Upland shrub communities can be established on east, south and west-facing slopes and in flat areas. Planting success likely will be highest if first plantings are concentrated in shallow depressions or draws. Potential species include willow, alder, red-osier dogwood, saskatoon, wolf willow, elderberry and wood rose. At maturity, shrub cover should be in the range of 25 to 75 percent; higher densities may restrict browsing and wildlife movements. Upland shrub communities are important as a source of winter browse and cover for ungulates and snowshoe hares.

6.3.3.5 Deciduous Forest. Deciduous forest communities dominated by aspen can be located in south to west facing areas with mesic to xeric moisture regimes. Mixed plantings of aspen and several shrub species such as saskatoon, wood rose, red-osier dogwood, buffaloberry and bearberry would provide varied habitat strata and food sources for ungulates, small mammals and passerines. In xeric sites, ground juniper could also be planted as a ground cover.

6.3.3.6 Mixed-wood Forest. Mixed-wood forests are best suited for mid- to lower slope locations with east, west or south-facing aspects. Species mixes may include trees such as aspen, lodgepole pine, Douglas fir, Englemann spruce and white spruce and shrub species such as red-osier dogwood, wood rose, saskatoon, high and low bush cranberry, alder and willow. This community can be established as an earlier successional stage for many of the coniferous-dominated communities (see below). At maturity, this community would provide a source of winter browse for ungulates and snowshoe hares, summer foods for small mammals and ungulates, and hiding cover and nesting sites for a number of passerine birds.

6.3.3.7 Coniferous Forest. Coniferous forest communities can be established in a variety of reclamation conditions. Alpine fir-white spruce forests can be established on north-facing slopes at mid to high elevations. Lodgepole or Jack pine-white spruce forests can provide good cover on flat or gently sloping north to northeasterly locations; alder is an important shrub component in this community. Lodgepole or Jack pine-black spruce communities are best located on mid to lower slope areas on northern, eastern or western aspects. Labrador tea, bog birch and bog cranberry should dominate the shrub stratum. Black spruce-tamarack forest communities can be planted in hydric to mesic sites on northern and eastern aspects or in flat areas. Dominant shrubs should include dwarf birch, willow and alder. During the first two decades after establishment, coniferous forests can provide some browse, hiding cover and reproductive cover for mammals and birds. At maturity, however, coniferous forests primarily provide thermal and hiding cover for wildlife plus food supplies for climax-adapted species such as red squirrels or caribou. Because coniferous forests provide only limited food supplies for most herbivores, coniferous units should be located in proximity to more open communities such as shrublands, deciduous forest, shrub meadows and grasslands, which offer a greater abundance and diversity of plant foods.

6.3.4 Placement and Structure of Vegetation Communities

Following selection of plant species appropriate for habitat reclamation and the physical conditions of the site, consideration must be given to the placement and interspersion of communities. Factors that should be considered include the size and spatial configurations of the units, and planting patterns within the units.

In the following discussion we have assumed that as a result of time and cost restrictions, the initial reclamation phase will concentrate on establishing shrub or tree habitat units interspersed with grasslands or shrub meadows. Additional tree and shrub units may then be established in the interstitial grassland areas as time, funds and materials permit. Natural invasion in the grassland areas will also expand the area of tree and shrubs (Game et al. 1982).

6.3.4.1 Sizes and Shapes of Habitat Units. The determination of optimum size or maximum-minimum ranges for habitat units is a difficult and complex task. Useable habitat unit sizes vary among wildlife species as well as among the types of habitat being reclaimed (Thomas et al. 1979a, 1979c). The surrounding habitat composition and topography in undisturbed sites also can affect the optimal size of reclaimed habitat units. Several studies have suggested that the size of the habitat unit (and shape of the unit) should be determined on the basis of the species' requirement for hiding cover in that habitat type plus an allowance for a core area for hiding and thermal cover in the centre of the habitat unit (Thomas 1979c; Marcot and Meretsky 1983).

Probably the most detailed information on habitat unit size is available for elk and deer as a result of an intensive wildlife-forestry study in the Blue Mountains of Oregon (Thomas 1979). Based on data for elk use of forest cover and openings (Reynolds 1962, 1966), Thomas et al. (1979c) suggested that the ideal cover: forage ratio for elk and deer was 40 percent cover to 60 percent forage. Thomas et al. (1979c) recommended that this ratio be used to guide forestry operations and reforestation plans such that 40 percent of the area was maintained or restored as forest cover and 60 percent as open grasslands or shrub meadows.

Based on Reynolds (1962, 1966) data, Thomas et al. (1976) also suggested that optimal hiding cover for elk is between 4 and 8 sight distances (e.g., 183 to 366 m) in width. Sight distance is defined as the width of a vegetation band capable of hiding 90 percent of an elk from a person. They also suggested that to maximize elk use, artificial openings should not have any point further than 183 m from cover, thus allowing for a maximum opening size of 366 m before additional cover units are required in an opening.

These distances have subsequently been used to determine the optimal size of undisturbed islands of habitat for elk (12 ha the approximate area of a circle with a radius of 183 m) (Thomas et al. 1979c) and the preferable opening size between areas of woody cover (366m) (e.g. Wallis and Wershler 1979; Westar Mining 1983). Restoration of cover:forage ratios for elk habitat also has been suggested as reclamation goals (Westar Mining 1983; Millson and Bondy 1984). Other work by Thomas et al. (1979c) suggests that thermal cover for elk on a summer or transitory range should consist of trees 12 m or higher, with an average canopy closure of 75 percent or more in habitat blocks of 12-24 ha.

Similar research on habitat requirements for wildlife in the Mountain and Foothill biomes of the prairie provinces is virtually non-existent. Some studies have been undertaken by the Alberta Fish and Wildlife Division to determine optimal cover: forage ratios for selected wildlife species but results are not yet available (Millson and Bondy 1984). Based on the Blue Mountains study (Thomas 1979), it could be suggested that optimal unit size for elk habitat is 12 ha with forage and cover units spaced at distances no greater than 366 m from each other. Such extrapolation is not without problems, however, and care should be exercised in the application of this information to the prairie provinces. Wildlife habitats, seasonal range use and hunting pressure in the Blue Mountains differ from those in the prairie provinces and, consequently, the sight distances and cover: forage ratios also may differ. For example, seasonal and elevational range use by elk in the vicinity of the Fording Coal mine near Elkford, B.C. is different from elk range use reported for the Blue Mountains and, as a result, critical spatial requirements may also differ (D. Lane, pers. comm.).

In Sections 7-9, habitat unit sizes are suggested for some of the key species. Most of the habitat unit sizes are based on available estimates of home range sizes that are applicable to similar habitats in the prairie provinces.

The shape of habitat units can also influence the use of habitat units by wildlife. In general, irregular shaped units will provide increased habitat edge which, in turn, benefits a variety of wildlife types (Thomas et al. 1979c; Marcot and Meretsky 1983). Irrregular shaped units are also likely to provide additional hiding cover and, because of the increased security for wildlife in these areas, will promote wildlife use. Marcot and Meretsky (1983) suggest a means of measuring stand shapes which might be useful in evaluating the proposed shape of habitat units within a reclaimed site and their value to wildlife.

6.3.4.2 Spatial Configurations of Habitat Units

6.3.4.2.1 Concept. Little site specific information on the spatial configuration of reclaimed habitat units is available for the prairie provinces since almost none of the existing and ongoing reclamation programs have considered the concept of planting vegetation communities (e.g., mixes of trees, shrubs and/or ground covers) and, hence, spatial configurations are of no concern. As discussed earlier, the physical features of a site (e.g., topography, watershed features) must dictate the planning and development of habitat units on a site. The spatial configurations of these units and the planting patterns within these units must, of course, also complement the physical features of the site.

Much of the revegetation efforts on reclaimed industrial sites in the prairie provinces has concentrated on reseeding of agronomic and/or native ground cover mixes to provide erosion protection, assist in soil reconstruction and promote nutrient cycling. Large numbers of tree seedlings have also been or will be established at some sites (e.g., Luscar, Gregg River and Obed mines; Suncor Inc.; Syncrude Canada Limited) to satisfy the Alberta Reforestation Guidelines. Within the Mountain, Foothill and Boreal Forest biomes, plantings generally have involved only commercial timber species with an emphasis on use of lodgepole or Jack pine and white spruce.

Use of shrubs on reclamation areas is a relatively new practice. Intermixed plantings of trees and shrubs to promote plant community development have been employed on a minor scale at the Suncor Inc. (T. Shopik, pers. comm.) and Syncrude Canada (D. Thompson, pers. comm.) oil sands mines and the Cardinal River (G. Acott, pers. comm.), Whitewood (Carbyn et al. 1984) and McIntyre (V. Betts, pers. comm.) coal mine sites. Community plantings also are planned at the Gregg River mine (M. Murphy, pers. comm.), the Westar mine (1983) and the McLeod River project (McLeod River Coal 1982). The Gregg River reclamation plan also includes the maintenance of islands of natural forest and shrub communities to promote natural invasion by plants (Hardy Associates 1982).

Clump or habitat unit plantings of woody vegetation can benefit wildlife in a number of ways. Once established, shrubs and tree cover can improve soil moisture by locally increasing snow accumulations, shading the soil and reducing wind evaporation (Tessman 1982). If topsoil supplies are scarce, topsoil islands provide one method of creating microsites with acceptable soil depths and quality. These benefits may, in turn, promote the natural invasion of woody species into adjacent areas.

Woody habitat units provide structural and botanical diversity, particularly when established in grassland areas (Krementz and Sauer 1982; Westar Mining 1983). Use of woody habitat units also increases the amount of edge and the availability of ecotone habitats to wildlife. Careful interspersion and shaping of woody habitat units can promote wildlife movements into and through the reclamation area by providing hiding cover and travel corridors (Stanlake et al. 1978).

6.3.4.2.2 Techniques. Techniques that have been implemented or proposed to establish woody vegetation for wildlife include shrub clusters, topsoil islands, forest stringers, hedgerows, transplanted vegetation islands and natural vegetation islands.

1. Shrub Clusters. Shrub clusters have been utilized or suggested in several wildlife habitat reclamation programs (Clausing 1981; Tessman 1982; WECO

1983; Westar Mining 1983) to improve soil moisture and to increase vegetation structure and diversity. Shrub clusters can provide nest sites for passerines as well as cover and browse for mammals and upland game birds (Krementz and Sauer 1982).

Shrub clusters can be encouraged by integrating shrub planting with the topography and soil moisture patterns. Most shrubs will grow well in lowlands, depressions, draws and on north-facing slopes. For example, shrub plantings by Parks Canada on a landfill reclamation site near Banff, Alberta, will be concentrated along the lower slope and bottom area of an artificially-created draw and in several depressions throughout the site (G. Harrison, pers. comm.). Plantings in these areas may perform better because of improved soil moisture conditions and may eventually provide browse and cover for elk coming onto the reclamation site. Tessman (1982) recommends that shrub clusters be planted exclusively with shrub stock and seed. Although aggressive species of herbaceous and graminoid ground covers should be discouraged until the cluster is well-established (in order to reduce competition for water and nutrients), less competitive covers such as peavine or strawberry can be planted. If dense ground cover already exists, the area should be scalped prior to planting of the shrubs or the vegetation removed with herbicides. Once shrubs and trees have been planted, herbicides should be used with caution as some products have been reported to damage well-established trees and shrubs, particularly conifers.

If shrub clusters are required on wind exposed slopes or ridgetops (e.g., as a component of ungulate winter range), it will probably be necessary to provide some physical protection for the shrub patch to reduce wind erosion and desiccation and to promote moisture accumulation (Tessman 1982; G. Acott, pers. comm.). Snow fencing has been used with limited success to protect island plantings at the Cardinal River Coal mine (G. Acott, pers. comm.). Rock walls and soil berms may also be useful in protecting shrubs in exposed sites.

2. Topsoil Islands. Topsoil islands, by providing a relatively thick, high quality growth medium, can accelerate the establishment of a woody vegetation community. The concept has been employed on an experimental basis at the Cardinal River Coal site (G. Acott, pers. comm.) and was to be incorporated into the wildlife reclamation plan at the Gregg River mine (M. Murphy, pers. comm.). At the Cardinal River mine, the reclamation site was capped with regolith and seeded with a grass-legume seed mix. Islands of topsoil were created by applying a 35 to 40 cm layer of topsoil in discrete patches. A mixture of coniferous trees and deciduous shrubs were then planted on the islands. Success to date has been limited because of the highly exposed nature of the site and trampling by bighorn sheep. Research on the island concept is ongoing with emphasis on the use of native shrubs; 15 species which occur locally are being evaluated for use.

   A preliminary study of the island concept (Wallis and Wershler 1979) suggested that tree islands be staggered along the perimeter and throughout the central portion of a mine site such that no island is more than 90 m from the undisturbed forest edge or an adjacent tree island (the 90 m distance is derived from line of site distances for elk that were derived by Thomas et al. [1976]) (Figure 9). Islands proposed for the Gregg River mine were to have been 3 ha in area with predominantly coniferous tree plantings (Hardy Associates 1982) but the concept was rejected by the Development and Reclamation Review Committee.

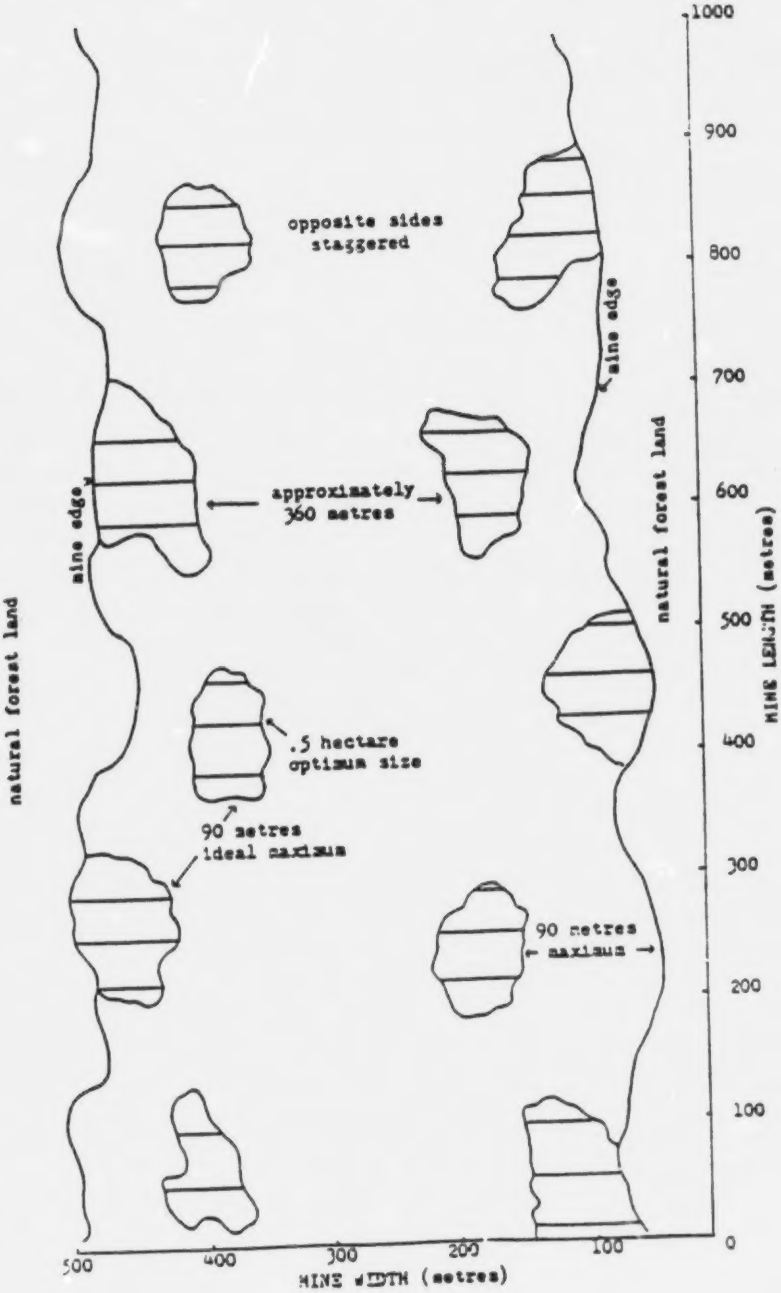
opposite sides staggered
mine edge
mine edge
natural forest land
natural forest land
approximately 360 metres
.5 hectare optimum size
90 metres ideal maximum
90 metres maximum
1000
900
800
700
600
500
400
300
200
100
0
MINE LENGTH (metres)
500
400
300
200
100
MINE WIDTH (metres)

Figure 9. Woody vegetation islands proposed for the Cardinal River mine site. (Source: Wallis and Wershler 1979).

Additional plantings of a mixed forest shrub community were to have been interspersed among the islands.

The proposed reclamation plan for Westar Mining (1983)(now approved) suggested a similar forest island concept, except that islands would be established on friable, uncompacted soil rather than topsoil deposits. Size, location and structure were to be determined on the basis of a number of site criteria and wildlife use. Tree and shrub species were recommended for four elevational strata and three slope positions within each stratum (Table 1).

3. Forest Stringers and Hedgerows. Forest stringers can be used to reduce wind exposure and soil moisture losses as well as to provide visual breaks and travel corridors for wildlife (Podoll 1979; Anderson and Markham 1981; Poston and Schmidt 1981; Westar Mining 1983; PRFA n.d. G. Harrison, pers. comm.). Depending on the width of the stringers, some species such as upland birds also may utilize these areas for nesting sites and escape cover.

Forest stringers have been used in a reclamation program for wildlife in the Healy borrow pit in Banff National Park. Narrow bands of the former white spruce forest cover were left between all of the pit cells to provide visual barriers and reduce the line-of-site distance (G. Harrison, pers. comm.). Forest stringers also have been employed in Montana (WECO 1983) and are presently being considered by several mines in the prairie provinces and British Columbia (Wallis and Wershler 1979; Westar Mining 1983; G. Acott, pers. comm.) to promote wildlife movements through and into sites. Wallis and Wershler (1979) suggested that individual stringers be established at intervals of approximately 1000 m, and that each stringer be continuous or with gaps no greater than 90 m. Forest stringers should conform to the natural topography of the site and complement natural ungulate travel corridors such as valley bottoms, draws and ridgetops (Westar Mining 1983; PFRA n.d.; G. Acott, pers. comm.; G. Harrison, pers. comm.). Anderson and Markham (1981) suggested use of hedgerows to promote wildlife movements to and from wetland areas and watercourses. Westar Mining (1983) may convert some of the abandoned haul roads on their site to wooded travel corridors for wildlife. Forest stringers also may be useful in providing protected corridors between bluffs or rock outcroppings (PFRA n.d.). Such corridors may be useful in encouraging movements of wildlife, particularly those with seasonal movement patterns, between suitable forage areas. If prevailing winds are common from more than one direction, L-, U- or E- shaped designs can provide increased protection for wildlife (Proctor et al. 1983).

Wide multirow shelterbelts provide better wildlife habitat than narrow, single-row plantings (Podoll 1979; Poston and Schmidt 1981; Proctor et al. 1983). Proctor et al. (1983) suggest a minimum of 10 to 15 rows for shelterbelts in areas subjected to blizzard conditions. Coniferous and deciduous trees should be planted in the central portion of the shelterbelt cross-section (Figure 10) with sequential rows of tall shrubs, low shrubs and tall ground covers (Poston and Schmidt 1981; PFRA n.d.). These mixed strata plantings offer better wind protection, promote snow accumulation and provide increased structural and floristic diversity in a relatively narrow space. Undulating or irregularly-shaped hedgerows provide more habitat edge and ecotone habitat as well as a reduced line of sight distance and improved hiding cover for wildlife (PFRA n.d.).

Table 1. Proposed species composition for three islands at the Westar Mine (Shedding, mesic and receiving refer to the influence of the slope on the water regime. Source: Westar 1983).

	Shedding Slopes	%	Mesic Areas	%	Receiving Areas	%
High Elevation East and North Facing Slopes						
	Engelmann Spruce	60	Engelmann Spruce	60	Mountain Alder	50
	Whitebark Pine	40	Mountain Alder	30	Engelmann Spruce	40
			Whitebark Pine	10	Willow	10
Low Elevation East and North Facing Slopes						
	Engelmann Spruce	70	Engelmann Spruce	60	Engelmann Spruce	40
	Lodgepole Pine	30	Wavy-leaved Alder	20	Wavy-leaved Alder	30
	Cottonwood	10	Cottonwood	10	Willow	10
					Red Osier Dogwood	10
					Cottonwood	10
High Elevation West and South Facing Slopes						
	Saskatoon	45	Lodgepole Pine	35	Trembling Aspen	50
	Rose	45	Whitebark Pine	10	Engelmann Spruce	20
	Oregon Grape	10	Trembling Aspen	35	Willow	20
			Saskatoon	10	Saskatoon	10
			Rose	10		
Low Elevation West and South Facing Slopes						
	Saskatoon	40	Western Larch	10	Douglas Fir	20
	Rose	40	Douglas Fir	10	Western Larch	20
	Oregon Grape	20	Lodgepole Pine	20	Spruce	10
			Trembling Aspen	20	Cottonwood	20
			Douglas Maple		Red Osier Dogwood	10
			Saskatoon		Willow	10
			Rose	40	Black Hawthorne	10
			Willow			
			Cottonwood			

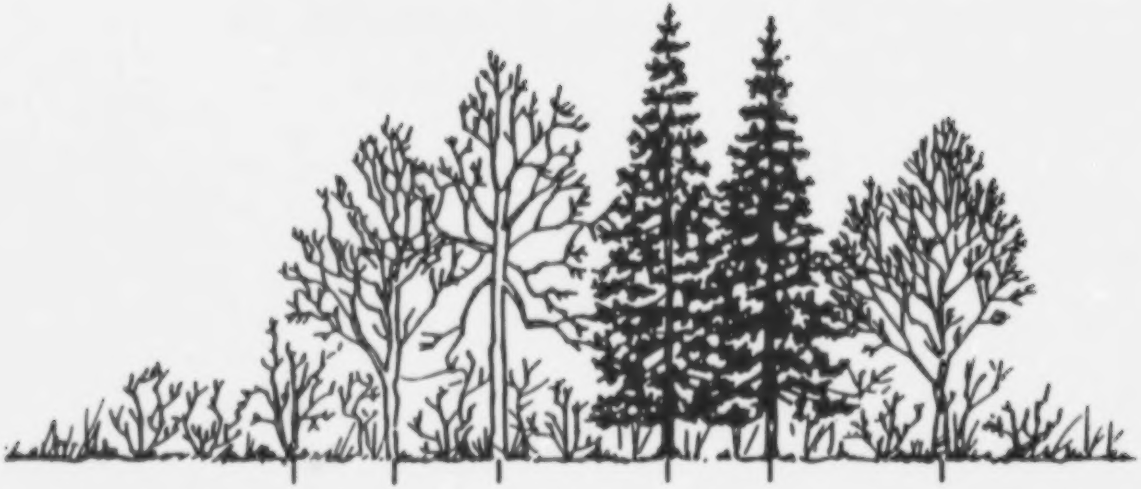

Figure 10. Schematic cross section of a hedgerow or forest stringer (Source: Poston and Schmidt 1981).

4. Transplanted Vegetation Islands. Transplanting clumps of natural vegetation communities from adjacent areas to reclaimed sites using tree spades and front end loaders has been used, with varying degrees of success in a number of reclamation programs (Sindelar et al. 1973; Svedarsky 1982; Tessman 1982; Proctor et al. 1983; WECO 1984; G. Acott, pers.comm., T. Shopik, pers. comm.). For example, clumps of frozen muskeg were moved from a proposed mine site to an overburden dump on the Suncor Oil Sands site near Fort McMurray, Alberta. Tree, shrub and ground cover established rapidly on the site from the transplant of live plants, the germination of natural seed within the soil and, eventually, reproduction from the re-established plants (D. Klym, pers. comm.; T. Shopik, pers. comm.). Transplants of native trees and shrubs have also been used on the Cardinal River mine site (G. Acott, pers. comm.). Although the transplanted trees and shrubs survived, no invasion of native species into the surrounding agronomic ground cover was observed. Transplants will also be used by Parks Canada to provide an immediate visual barrier between a highway access ramp and a reclaimed borrow pit (G. Harrison, pers. comm.). When transplants are used, however, care must be taken to pack soil material around the root mass and seal the clump edges in order to reduce aeration and drying of the root ball. Root pods should also be placed to take advantage of runoff or stored moisture (WECO 1984). Sindelar et al. (1973), for example, suggested that transplanted clumps be placed in depressions in order to channel water towards the vegetation island. Small rodents can damage root pads by tunnelling and severing roots (WECO 1984) and appropriate precautionary measures should be taken when locating root pads in areas of established vegetation cover (see Section 10.2).

5. Natural Vegetation Islands. Preservation of islands of natural wooded vegetation can provide immediate cover and forage for some species of wildlife while at the same time augmenting natural dispersal of native plant seed into reclaimed areas (Stanlake et al. 1978; Hardy Associates 1982; Tessman 1982; Carbyn et al. 1984). Stanlake et al. (1978) evaluated ungulate use of three abandoned mine sites in British Columbia, and noted that intact vegetation islands were used intensively by ungulates for cover during use of or travel through the disturbed areas. The location of intact natural islands should complement the operational mine plan. Wide-scale clearing of the mine site should be avoided and as many vegetation islands as possible should be left within the mine development site.

6.3.5 Planting Configurations Within Habitat Units

Because of the small number of wildlife habitat reclamation programs that have been implemented in the prairie provinces (or elsewhere), little information is available on optimal planting configurations for wildlife use.

6.3.5.1 Planting Patterns. Schematic configurations for structuring habitat blocks, primarily windbreaks, have been proposed for some wildlife uses (Poston and Schmidt 1981; Proctor et al. 1983; PFRA n.d.). A possible planting structure for forest stringers or hedgerows has already been discussed (Figure 10).

6.3.5.2 Plant Spacing. Literature is available on plant spacings for successful reforestation and revegetation (AFS 1979; Watson et al. 1980) but little information was found that addressed the optimal stocking rates for effective restoration of tree and shrub cover for wildlife use. The Alberta Forest Service Regeneration Guidelines (AFS 1979) recommend a minimum stocking rate of 1 seedling/8 m^2 or 1250 seedlings/ha. On the Gregg River mine site, proposed stocking rates were 1100 trees/ha with spacings of 3m x 3m. This was estimated to provide a minimum of 800 trees/ha by the end of the first growing season. Shrubs were to be planted in clumps of 2 to 5 seedlings with a minimum 2 m spacing between clumps.

At the Westar mine (Westar Mining 1983), stocking rates differ according to planned habitat type for a site. Shrubs are to be planted at 10 to 20 m spacings in grassland sites and at 3 to 5 m spacings in proposed winter range sites. In forest island plantings, stocking rates for all trees and shrubs combined will be 2000 stems/ha, with irregular spacing to promote a mosaic planting pattern and uneven edge.

For windbreaks, Proctor et al. (1983) suggested spacings of 1 to 1.2 m x 3.7 to 4.6 m for shrubs, 1.8 to 2.4 m x 3.7 to 5.5 m for low to medium trees and 2.4 to 3.0 m x 3.7 to 6.1 m for tall bushy trees. Closer spacings were recommended for the windward edges of shelterbelts to provide increased wind protection and reduced snow drifting within the shelterbelt.

6.4 SPECIAL STRUCTURES

A variety of structures and techniques have been used to provide immediate improvements in structural and topographic diversity of wildlife habitat in disturbed areas; these include enhancement of highwalls, creation of rock talus, rock piles and brush piles, placement of logs, stumps, snags and construction of artificial nesting structures.

6.4.1 Enhancement of Highwalls

6.4.1.1 Concept. During the development of some reclamation sites, many of the abrupt topographic features such as cliffs, gullies, badlands and rough breaks are altered. Because some of these features represent erosional formations, they are difficult to reconstruct. However, if the final cuts in an excavated area are in erosionally stable material, the highwall could be enhanced for wildlife use (Tessman 1982; WECO 1982; Westar Mining 1983). By increasing the structural diversity of a site, highwalls and other abrupt topographic features can provide attractive habitat features for some wildlife and improve wildlife diversity (Steele and Grant 1982).

Cliff habitats provide shelter, escape corridors, visual barriers, nest and den sites, perch and roost sites, and loafing sites for a number of species (Kimmel and Samuel 1978; Maser et al. 1979a; Marion et al. 1981; Tessman 1982; Parmenter et al. 1985). If properly integrated with the surrounding landscape, revegetated and abutted with talus slope, reclaimed highwalls can also increase the aesthetic appeal of the site.

Highwalls have been maintained as part of the wildlife reclamation program at the Western Energy mine in Montana (WECO 1982) and are to be incorporated into the reclamation plans at the Cardinal River (G. Acott, pers. comm.), Gregg River (Hardy Associates 1978), Crowsnest Resources (B. Densmore, pers. comm.) and Westar Mining (1983) sites to provide escape terrain for bighorn sheep. Raptor nesting on the highwalls will be encouraged at all of these mines.

6.4.1.2 Technique. Highwall reclamation is most valuable in areas where natural bluff and cliff habitats are scarce. If intended as escape terrain for bighorn sheep or mountain goats, grassland areas should abut the formation on both the top and bottom of the highwall since proximity of the highwall to dense forest cover provides predators with easy access to bighorn sheep and mountain goats (W. Wishart, pers. comm.).

Igneous, metamorphic and competent sedimentary material are the preferred rock base for highwalls that are to be enhanced for wildlife, as most other base materials will erode easily or slump (Maser et al. 1979a). If the bedding planes of the rock, or the composition of the highwal may result in large scale wall failures, the highwall should be recontoured. Highwalls should also be located perpendicular to the slope contours and near the top of a divide rather than parallel to the contours or in a drainage bottom (Tessman 1982). Tessman (1982) provided a number of general suggestions for highwall development in Wyoming (Table 2). Maser et al. (1979a) indicate that increasing cliff height provides more suitable habitat for wildlife. With increasing height, upward-flowing warm air currents (thermals) are more predictable and suitable for raptors. Cliffs within 400 m of water are also more suitable for wildlife use (Maser et al. 1979a).

If the highwall is intended as escape terrain for bighorn sheep or mountain goats, surficial alterations of the highwall face may be necessary to provide adequate escape routes. Ledges should be constructed to provide interconnected routes up the cliff face and into the adjacent areas around the cliff face. Bighorn sheep on the Cardinal River mine site frequently utilize the safety benches and existing routes up the highwall (G. Acott, pers. comm.). Helicopter seeding of the safety benches was recently completed to provide some forage on or adjacent to the newly-created escape terrain. At the Gregg River and Crowsnest Resources mines, all highwalls with slopes greater than 27° and 37°, respectively, are to be left as escape routes for wildlife (G. Acott, pers. comm.; B. Densmore, pers. comm.).

Ledges or shallow caves in the cliff face can be created to provide raptor and corvid nest sites (Maser et al. 1979a; Tessman 1982; WECO 1982). Blasting of holes in the highwall face was suggested in the reclamation plan for the Gregg River mine as a means of creating nest sites for birds (B. Martens, pers. comm.).

6.4.2 Talus

6.4.2.1 Concept. Talus is usually associated with cliff habitats and should be incorporated into most highwall enhancement projects. Talus provides reproductive and hibernation habitat for a number of species of small mammals and birds (Maser et al. 1979a). The pika is the only obligate talus species of wildlife in the prairie provinces but ground squirrels (golden-mantled, Columbian), hoary marmots, and bushy-tailed wood rats also frequently inhabit talus. Depth of talus and interstices among the rocks are important as they permit animals to move inside the talus to the right temperature and humidity regimes. Talus also provides access to highwall habitats (Tessman 1982).

6.4.2.2 Techniques. Talus should preferably be composed of large metamorphic rocks as opposed to small rubble or sedimentary rocks, because the latter two types erode easily and do not provide stable living places for wildlife (Maser et al. 1979a). Talus of varying heights (and depths) provides a greater diversity of microsites (Tessman 1982). Larger talus areas also are preferable because they provide more habitat and are more stable than small talus areas (Maser et al. 1979a).

6.4.3 Rock Piles

6.4.3.1 Concept. Rock piles can be used to provide immediate cover for wildlife, particularly during the first several years after reclamation when vegetation cover is sparse. They can provide den sites, shelter and hibernacula for small mammals and raptor nest sites

Table 2. Habitat considerations and specifications for highwall reclamation (Modified from Tessman 1982).

Consideration	Specifications
Length	The applicant should provide a biological justification for whatever length is selected. Smaller broken segments are preferred over a long continuous wall.
Height	The maximum height will be limited by safety and stability considerations. If possible, the height should be varied through the length of the highwall.
Configuration	The face should undulate in horizontal cross-section (i.e., the wall should project inward and outward) to provide visual barriers between raptor nest sites. The slope angle of the wall should also be varied. South facing cliffs are preferred for bighorn sheep and mountain goats.
View	A broad view from the face of the wall is preferred for raptors. Hence, the opposing slopes should be graded to the base as gradually as possible, rather than left steeply facing the wall.
Ledges	Recommended dimensions are 0.5 - 2.0 m in width and 2 - 10 m in length. A variety of ledge widths, lengths and heights should be used to provide a variety of nesting, perching , roosting and loafing sites for raptors and other birds. Ledges for bighorn sheep and mountain goats should provide access routes up and across the cliff face.
Holes	Holes should be blasted or drilled into the cliff face. Recommended dimensions are 0.5 - 2.0 m in diameter and 0.5 - 2.0 m deep. Mixes of different sized holes should be used to provide a variety of sites for birds and small mammals.
Talus Slopes	Talus slopes should consist of rock debris piled to varying heights along the base of the wall. Such debris may be deposited by blasting or free-dumping. Predominantly large-sized rocks (0.5 - 1.5 m) should be used to provide interstices for small mammals and birds. Talus slopes should be broken rather than continuous.
Access Corridors	Access corridors should be provided through several areas in the wall to allow animals to ascend the wall without going around the outside edges. Access corridors can be created by blasting or dumping of overburden up to the top of the wall. One to three sites are sufficient per 400 m of highwall length.
Vegetation	Species adapted to natural cliff habitats should be used whenever possible. Woody species might include juniper and mountain mahogony. Moist conditions will likely occur at the base providing suitable conditions for a variety of shrubs. Ledges also offer shrub sites. Forest cover should be removed at least 150 m back from the cliff top and face to reduce hiding cover for potential predators of bighorn sheep and mountain goats.
Waterbodies	Small waterbodies (i.e., < 20 acres) can provide a readily accessible water source for some species as well as a hunting area for raptors. Waterbodies can be formed by filling of end pits next to the wall, blasting or excavation. Waterbodies should preferably abut talus slopes rather than the cliff face to prevent erosion and undercutting of the highwall.

and perches (Maser et al. 1979b; Szafoni 1982; Tessman 1982; Proctor et al. 1983). They also provide immediate topographic diversity on a local scale and are particularly valuable to wildlife when constructed in association with waterbodies (Szafoni 1982). Westar Mining (1983) has incorporated several rock piles in their wildlife reclamation plan. At the Cardinal River mine site, free-dumped talus with a slope of approximately 80% was routinely used as escape terrain and travel routes by bighorn sheep (G. Acott, pers. comm.).

6.4.3.2 Technique. Rock pile height should be 1 to 4 m and occupy an area of less than 10 m^2 (Szafoni 1982; Tessman 1982; Proctor et al. 1983). Lengths can be variable and, in some cases, rock piles can be created to provide a windbreak for vegetation (e.g., shrub clumps) as well as wildlife habitat. Rock piles also can promote snow accumulation and increased soil moisture (Tessman 1982).

Rock piles are most useful to wildlife if the core of the pile is constructed of 1 to 3 large boulders, 1 to 4 m in diameter, surrounded by smaller rocks 1 m in diameter or less (Tessman 1982). They do not need to be neatly constructed as irregular edges and heights increase their attractiveness to wildlife. If rock piles are intended for use by raptors, they are best located near hilltops. In contrast, valley bottoms, draws and protected hillsides are optimum locations of rock piles for mammals (Tessman 1982; Proctor et al. 1983).

6.4.4 Brush Piles

6.4.4.1 Concept. Woody vegetation removed during the clearing of the mine site can be used to provide immediate cover for birds and mammals. Brush piles provide similar benefits as rock piles (Section 6.4.3) but are only a short-term measure. Because they may become a fire hazard, brushpiles should be located in areas where risk of fire is low.

6.4.4.2 Technique. Brush piles can be constructed as mounds or hedgerows (Szafoni 1982; Proctor et al. 1983) and can be combined with rock piles to provide temporary cover (Proctor et al. 1983). To maximize wildlife use, brush piles should be constructed over a bowl-shaped depression and a log or rock base to provide clearance in the pile. Larger brush (up to 5 cm twig diameter and 1.2 m lengths) is the preferred construction material and should be anchored by pushing the branches into the soil or securing with wire or rocks (Tessman 1982; Proctor et al. 1983). Brush piles can be constructed to provide some protective cover along travel corridors, or near waterbodies for cover and nesting sites (Proctor et al. 1983).

6.4.5 Downfall, Stumps and Snags

6.4.5.1 Concept. Downfall, deadfall, stumps and snags are natural components of all forest ecosystems and provide important microsites for wildlife use. They are used as perching, nest and den sites (Maser et al. 1979c; Tessman 1982). Downfall, deadfall and stumps also encourage arthropod colonization with subsequent benefits in nutrient cycling and provision of a prey base for some birds and mammals. They are also important in mycorrhizal colonization (Maser et al. 1979c) and, by providing protection to newly-established seedlings, may improve seedling survival (Westar Mining 1983). The utilization and value of snags to wildlife has been reviewed by USDA (1983). The wildlife reclamation plan at the Westar mine includes deadfall placement. Snags have been used to attract wildlife at the Cardinal River (G. Acott, pers. comm.) and Westar mines (Westar Mining 1983).

6.4.5.2 Technique. Logs and stumps should be oriented perpendicular to the slope of the hill in order to serve as a sediment trap and moisture (Maser et al. 1979c). Large diameter logs are preferable to small diameter logs because the amount of cover for wildlife increases with log diameter. Because the value and uses of logs and stumps to wildlife are modified with decomposition (Maser et al. 1979c), logs of varying states of decay should be used.

Snags should be at least 20 to 30 cm DBH and 5 to 10 m in height (Thomas et al. 1979d; Tessman 1982; Westar Mining 1983). The base should be firmly anchored in rock or concrete. If use by raptors is intended, snags should be placed near hilltops on the leeside of the prevailing winds. Snags can also be placed near waterbodies and riparian zones. A mix of hard and soft snags (i.e., varying states of decay) is preferred; however, soft snags may collapse when moved and hard snags are more easily handled (Westar Mining 1983).

6.4.6 Artificial Nest Structures

6.4.6.1 Concept. Artificial nest structures can be constructed to replace nesting sites for cavity-nesting birds (e.g., owls, woodpeckers and some passerines), and platforms can be used during initial stages of reclamation as nesting sites normally provided by large mature trees (Allaire 1979; Szafoni 1982; Proctor et al. 1983). Nest boxes and platforms can also be used in wetland developments to provide nesting sites for cavity-nesting ducks (e.g., buffleheads), dabbling and diving ducks and geese (Szafoni 1982; Proctor et al. 1983; Poston and Schmidt 1981). Suncor Inc. (D. Klym, pers. comm.), TransAlta Utilities (Scheideman and Stelfox 1981), Western Energy Mines in southeastern Montana (Dahmer et al. 1982) and Decker Mines in southeastern Montana (Lockhart et al. 1977) have utilized nest boxes to attract raptors (e.g., American kestrel) and passerines to their reclamation sites and to increase nesting success.

6.4.6.2 Techniques. Because different bird species require different types of nest boxes for successful nesting, boxes must be constructed with specific key species in mind (Table 3) (Kalmbach et al. 1969, cited in Proctor et al. 1983). Proctor et al. (1983) review the use of boxes, platforms, baskets, cones and burrows for a number of bird species. Poston and Schmidt (1981) provide specifications for several nesting structures for waterbirds.

6.4.7 Artificial Salt Licks

Ungulates make frequent use of natural mineral licks (e.g., Cowan and Brink 1949; McCrory 1969; Stelfox 1978; Holroyd and VanTighem 1983). However, the nutritional significance of mineral licks is poorly understood for most species of ungulates (see habitat requirement reviews in Volume II). Bighorn sheep, mountain goats, elk and deer will use artificial mineral sources such as salt blocks, highway salt and mineral spills from trains (Wishart 1958; Stelfox 1978; Kuhn and Martens 1980; Berg 1983) and artificial sources of salt may be useful in attracting ungulates to a reclamation site. However, because use of salt blocks has been linked to the spread of contagious ecthyma (a potentially debilitating disease to sheep and goats, in particular) artificial salt sources should only be provided under advice of provincial wildlife managers.

During the initial inventory of wildlife habitats on a development site, mineral licks on or adjacent to the development site should be identified. If an on-site lick cannot be left intact or if additional licks may be developed as part of the reclamation plan, the mineral content of the natural licks should be determined. Then if ground water seeps are exposed during excavations or site development and are of a suitable mineral content, they could possibly be developed as artificial licks.

Table 3. Nest box dimensions and placement heights (Source: Proctor et al. 1983).

Species	Floor of Cavity cm	Depth of Cavity cm	Entrance above Floor cm	Diameter of Entrance cm	Height above Ground[1] m
Bluebird	13 x 13	20	15	4	1.5 - 3
Robin	15 x 20	20	([2])	([2])	1.8 - 4.5
Chicadee	10 x 10	20 - 25	15 - 20	3	1.8 - 4.5
Nuthatch	10 x 10	20 - 25	15 - 20	3	3.6 - 6.0
House Wren	10 x 10	15 - 20	3 - 15	2.5 - 3	1.8 - 3
Swallows	15 x 15	15	3 - 13	4	2.4 - 4.5
Phoebe	15 x 15	15	([2])	([2])	2.4 - 3.7
Flycatchers	15 x 15	20 - 25	15 - 20	6.5	1.8 - 6
Flicker	18 x 18	41 - 46	36 - 41	6.5	1.8 - 6
Downy Woodpecker	10 x 10	23 - 30	15 - 20	3	1.8 - 6
Hairy Woodpecker	15 x 15	30 - 38	23 - 30	4	3.7 - 6
Screech Owl	20 x 20	30 - 38	23 - 30	7.5	3 - 8
Saw-whet Owl	15 x 15	25 - 30	20 - 25	6.5	3.7 - 6.0
Barn Owl	25 x 46	38 - 46	10	15	3.7 - 5.5
Sparrow Hawk	20 x 20	30 - 38	23 - 30	7.5	3 - 9

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1. Data indicate that boxes at moderate heights, mostly within reach of a man on the ground, are readily accepted by many birds.

2. One or more sides open.

Artificial mineral licks were suggested in the Elk River environmental impact assessment as one of the means of attracting elk to newly-constructed movement corridors (B. Martens, pers. comm.). In the environmental impact assessment for the Mt. Brussilof development, it was recommended that existing dry licks be replaced with artificial licks but that the locations of the new licks be more widely dispersed to avoid potential disease problems (B. Martens, pers. comm.). However, within the Athabasca oil sands area, moose have been observed to use ground water seeps (with high salt content) that were exposed during the formation of the Athabasca River valley. Since the same formations are exposed during open pit mining at several existing oil sands mines (e.g., Suncor Inc. and Syncrude Canada Ltd.), it is possible that ungulates could be encouraged to use newly-exposed seeps in these mining areas.

6.4.8 Sound Attractants

Sound attractants have been used on the Western Energy mine site in Montana to attract sharp-tailed grouse to substitute dancing arenas in reclaimed areas (Waage 1984). Both dancing arenas were elevated knolls and were moved to provide open sites within the grassland area. During the spring nesting period, tape recordings of grouse display sounds were played back daily through an automatic system near the display arena. Grouse decoys also were positioned in proximity to the dancing sites. Birds were attracted to the site and eventually established a new dancing arena close to the site of the artificial dancing ground. No examples of the use of sound attractants on reclaimed areas is known in the prairie provinces.

7.0 BOREAL FOREST BIOME

7.1 BIOME DESCRIPTION

The Boreal Forest biome incorporates the Boreal Mixedwood, Boreal Foothills, Boreal Northlands and Boreal Subarctic wildlife habitat regions of Knapik and Westworth (1984) and with slight boundary modifications the same-named ecoregions of Strong and Leggat (1981). It covers virtually the entire northern half and much of the west central part of Alberta and the northern halves of Saskatchewan and Manitoba (Rowe 1972) (Figure 1).

The Boreal Mixedwood habitat region comprises most of the biome. A variety of landforms and topography occurs in the region, although relief is generally subdued. Vegetation cover on well-drained sites is dominated by aspen (and scattered grasslands), with secondary quantities of balsam poplar and white spruce on moderately well-drained areas, and jack pine communities on sandy parent materials. Poorly drained sites support black spruce muskeg, willow shrubland, sedge meadow or other wetland vegetation. Vegetation cover of the Boreal Northlands habitat region is similar, with the exception that white spruce forms a relatively more dominant component of the vegetation. The Boreal Subarctic habitat region is distinguished by widely spaced black spruce tree cover, moss ground cover and discontinuous permafrost; it coincides with highland areas in the northwestern part of the province. We have also included the Boreal Foothills habitat region in this biome, although strictly speaking it is an ecotone between boreal and cordilleran vegetation. Codominant aspen, balsam poplar, lodgepole pine and white spruce form the modal vegetation, although paper birch, black spruce and fir also occur, as do black spruce, willow and sedge-dominated vegetation types.

The predominant use of this biome is for forestry, although agriculture (forage and crop production, grazing) has become established where local conditions permit. The biome is an important wildlife habitat due to its extent and the generally low level of development.

7.2 KEY WILDLIFE SPECIES

Key species selected for this biome include two wetland species (beaver and muskrat), three species adapted to forest edges, openings and/or early successional vegetation (mule deer, moose and sharp-tailed grouse), and one species adapted to mature climax forests (caribou). Specific habitat requirements of these key species are described in detail in Volume II.

7.3 INDUSTRIAL DISTURBANCE AND RECLAMATION

The major types of industrial activity in the Boreal Forest biome are open-pit oil sands facilities (such as Suncor Inc. or Syncrude Canada Limited), in-situ oil sands facilities (the Esso Cold Lake project) borrow pits, and linear right-of-ways (ROW) such as pipelines or seismic lines. Because of the generally subdued relief in the Boreal Forest biome, most developments that involve excavation of materials will create above-grade features such as storage piles that are atypical for the biome as well as sub-grade pits or basins.

Open pit oil sands developments within this biome are presently concentrated in the Athabasca Oil Sands formation north of Fort McMurray, Alberta. During the mining process, topsoil and muskeg is first stockpiled for later use and the underlying mineral soils and low quality oil sands (overburden) are removed. The overburden and processed oil sand are stored permanently in either large above-grade stockpiles or are used to fill completed mine pits. However, because the processed oil sand and overburden can occupy as much as 130% of its original volume, large above-grade stockpiles are a necessity. Overburden stockpiles are generally multi-tiered and solid cored. Tailings sand stockpiles usually consist of multi-tiered dikes surrounding a central water and clay sludge lagoon. Although there is margin for slight modification of the stockpile designs (e.g., rougher terrain, uneven terraces), structural integrity of the stockpile lifts is essential to prevent slope failure (S. Stephansson, pers. comm.) At completion, it is anticipated that the lagoons will be drained and detoxified, filled with tailings sand and capped with topsoil (T. Shopik, pers. comm.).

Present revegetation scenarios on the Suncor Inc. oil sand site call for development of at least 6 vegetation communities on the reclaimed mine site (D. Klym, pers. comm.; T. Shopik, pers. comm.).

1. Balsam poplar - willow community on the central depressional area of the plateau on the tailings sand stockpile;

2. Jack pine - lichen forest on the outer edges of the plateau and upper slope areas of the tailings sand stockpile;

3. Jack pine - aspen forest on the mid-slope of the tailings sand plateau.

4. Balsam poplar - white spruce forest at the base and lower slopes of the tailings sand stockpiles;

5. White spruce - aspen mixed woods on the overburden stockpiles; and

6. Bog/fen associations on the plateau of some overburden stockpiles or in excess muskeg storage areas.

The reclamation plan for the Alsands development was also to have included the development of similar types of vegetation communities.

In-situ oil sands projects have been developed in the Cold Lake area (the Esso Resources Cold Lake project) and the Athabasca Oil Sands area (several in-situ research projects have been constructed by Gulf Canada Resources, Chevron Oil and the Alberta Oil Sands Technology and Research Authority). In all cases, site disturbances primarily involve the clearing of forest cover within the plant area and well pads, and the construction of access corridors for roads and pipelines between these sites. Extremely little excavation of sub-surface material is required. However, top-soil may be removed from some development sites and stored for later replacement. Reclamation of wildlife habitat in these projects would primarily involve re-establishment of vegetation communities and habitat enhancement in surrounding areas (G. Lambert, pers. comm.; G. Mann, pers. comm.). Storage sites for elemental sulphur and coke (removed during oil processing) will require soil treatments to improve the soil chemistry but may also be reclaimed for wildlife habitat.

If built to a standard design, most borrow pits in the biome will likely involve small areas (e.g., 2-10 ha) and rectangular to square excavations with depths of several meters. Topsoil must be salvaged and stockpiled and returned to the site when the pit is completed. Reclamation in these sites generally involves recontouring of the side slopes (e.g., 30% slopes), replacement of topsoil and revegetation using grass-legume seed mixes. In some cases, all or part of the excavation may contain water.

Although linear ROWs may involve some disturbance of soils (e.g., for pipelines) , the surface topography is generally returned to almost the same conditions as existed prior to disturbance or is not disturbed. Forest cover is removed from the ROW during construction but, depending on the ROW use, revegetation may occur within the first or second season after disturbance. Revegetation of the ROW with agronomic grasses and legumes often utilized for drainage and erosion control. Because of the narrow width of most ROWs, the requirement for access during operation, and the extensive habitat edge with natural communities, potential for reclamation of wildlife habitat on ROW's is restricted. However, materials storage sites, construction camp sites, borrow pits and other ROW-associated structures offer good potential for restoration and enhancement of wildlife habitat.

7.4 WILDLIFE HABITAT RECLAMATION TECHNIQUES FOR THE BOREAL FOREST BIOME

None of the past or current reclamation programs in this biome have directly addressed wildlife habitat as a primary or secondary objective of the reclamation program. Most of the existing reclamation areas focused primarily on the stabilization of tailing sand and overburden piles through revegetation. A number of research programs have also addressed soil development and amendments, revegetation success and plant propagation. A current study by Suncor Inc. is examining potential sites for vegetation community development and suitable species mixes (ground cover, shrubs and trees) for these communities (T. Shopik, pers. comm.). Syncrude Canada Limited has also conducted a number of studies on propagation and establishment of native shrubs and trees (Fedkenheuer 1979a, 1979b). Although experience with wildlife habitat is limited in this biome, reclamation of wildlife habitat will be one of the primary end uses for reclaimed sites since forestry potential in the area is poor to moderate and agricultural potential is poor to nil. Reclamation plans for the Syncrude, Suncor, Canstar and Alsands projects on the Athabasca Oil Sands all include wildlife habitat reclamation as a major land use goal (D. Thompson, pers. comm.; D. Klym, pers. comm.; S. Stephansson, pers. comm.; D. Dabbs, pers. comm.) but no field programs have been initiated since none of the operational projects will abandon any portions of their leases until the mid-1990's.

7.5 RECOMMENDED RECLAMATION TECHNIQUES FOR KEY SPECIES

Specific techniques for reclaiming habitat for each of the key species in the Boreal Forest biome are summarized in Tables 4 - 9. Modifications to the general techniques described in Section 6 are provided, where possible, to better adapt the techniques to conditions in this biome. Potential uses of grasses, forbs, shrubs and trees for wildlife habitat reclamation are summarized in Table 10.

Table 4. Reclamation objectives for beaver in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Only effective within 245 m of a permanent waterbody or watercourse (maximum foraging range of beaver from water) and most effective within 30 m. - Recontouring should focus on the creation of smooth gently-sloping (<25%) or rolling terrain to permit access by the animals and movement of food materials. - Recontouring or creation of drainage channels should provide shallow gradients (<5-7%) with well-defined banks and broad mesic flood plains (e.g., 45 m wide).
Watershed Re-establishment	- Minimum area of 0.8 km of stream or 1.3 km^2 of lake/marshland habitat is required. - Watercourse design should include a low gradient (5-7% slope is optimum), a meandering channel, well-defined banks (to permit the construction of stable dams) and clay soils (to ensure water retention). Water flows should be sufficient to maintain water depths of 0.9-1.5 m behind a dam. - Waterbodies should include irregular shorelines, clay substrates and water depths of 0.9-1.5 m. If damable, beaver will modify water depths to preferred levels.
Revegetation	- A willow-aspen community is most desirable within 30 m and up to 245 m from water. Both species provide a good source of food and building materials. Willows also help stabilize watercourse banks. - Willows are best established in riparian and other hydric sites (e.g., bottom depressions) using large numbers of cuttings that have been treated with rooting hormone. - Balsam poplar, alder, paper birch, dwarf birch are also suitable woody species for revegetation. - Water lilies are a preferred food and can be planted in reclaimed waterbodies. - Conifers are not commonly utilized by beaver and therefore are suitable for planting in areas where it is desirable to discourage beaver activity.
Special Habitat Features	- Because beaver rely on woody plants for food, they may retard re-establishment of trees and shrubs. However, they are a useful key species because of their ability to regulate water levels and create water impoundments which, in turn, are beneficial to a large number of mammals and birds.

..... Table 4 continued

Table 4 concluded.

Technique	Recommended Specifications
	- Beaver can be maintained on a site by providing food and construction materials, particularly during the late summer and fall when food caching and construction are at a peak. Freshly cut willows and aspen from adjacent natural areas will be utilized by beaver if provided close to the waterbody or watercourse.
Additional Benefits	- Reclamation of beaver habitat will provide habitat for diving and dabbling waterfowl, semi-aquatic mammals such as mink and otter, and improved water supplies for terrestrial wildlife. Waterlilies may also be used by moose. Riparian shrub and tree communities will provide woody browse for ungulates and snowshoe hares.

Table 5 . Reclamation objectives for muskrat in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Because of the aquatic habits of this species, topographic modification is only applicable to design of waterbodies and watercourses (see below).
Watershed Establishment	- Based on home range sizes, waterbodies must provide a minimum of 200 m^2 of marshland habitat. - Overwintering water depths must exceed 0.7 m. - Watercourse habitats should have shallow gradients (3-5%), low water velocities, convoluted channels, and some well-defined clay banks (for construction of bank dens). - Waterbodies should have irregular shorelines and contain large areas (50-60% of pond) with water depths of 0.5-1.5 m to promote development of emergent aquatic vegetation. - Bottom substrates in waterbodies should be capped with a topsoil and hay mulch amendment to promote emergent growth. - Water levels in wetlands or ponds should be severely reduced during the summer period once every 5-7 years to maintain vigorous growths of aquatic plants.
Revegetation	- Two vegetation communities should be established: aquatic plants and riparian shrub. - Aquatic plants should include emergent plants such as bulrushes, cattails and reeds and submergent/floating plants such as duckweed or pondweed. Establish through direct transfer (of rhizomes and live plants, respectively), innoculation of waterbody with bottom substrates from natural wetlands or direct seeding (collections of natural seed will be required). These plants provide an essential food source and construction material. Emergent plants should eventually occupy 50-60% of the pond area. Establish riparian shrub communities along streambanks and shorelines for stabilization using large numbers of fresh willow and alder cuttings (treated with rooting hormone).
Special Habitat Features	- Not applicable
Additional Benefits	- Reclamation for muskrats will provide good habitat for dabbling waterfowl, shorebirds, marsh-associated songbirds, semi-aquatic mammals and amphibians as well as a water source for terrestrial wildlife. Riparian community development will benefit ungulates and small mammals (e.g., snowshoe hares).

Table 6. Reclamation objectives for caribou in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Use flat or rolling terrain with moderate slopes and a variety of exposures. - Above-grade recontouring should provide some rolling terrain through free-dumping and recontouring or through selective creation of depressions on spoil piles (e.g., along lift terraces). - Specialized shaping of spoil piles also can be used to create an undulating terrain with diverse slopes and aspects. - Alternatively below-grade pits and above-grade spoil piles can be used to create rolling terrain.
Watershed Re-establishment	- To promote development of black spruce forest in depressional areas, drainage in the lower depressional areas of the site should be minimized.
Revegetation	- Revegetation difficult because of the long-term period required for habitat development (e.g. prefer climax forests) and preference for specialized foods (terrestrial and arboreal lichens) in addition to some graminoids, forbs and shrubs - Provide intermix of closed coniferous forest, open coniferous forest and open meadows by altering planting densities of seedlings. - Establish black spruce forest communities in depressional sites; important understory species include Labrador tea, dwarf birch, blueberry, cloud berry and willows. - Establish conifer-dominated (white spruce, black spruce and balsam fir) forests on slopes surrounding depressional sites; underplant with similar understory to black spruce forest. - Habitat units should be a minimum of 400 m wide in order to eventually provide protective cover; larger blocks of conifer forests are desirable to promote lichen development. - Maintenance of large islands of natural conifer cover (minimum of 2 ha) may provide some useable immediate cover; dense clump plantings and stringers of conifers and associated understory should be used to break up the visual expanse of the site. - Development of acceptable habitat may require period of 75-100 years.

..... Table 6 continued

Table 6 concluded.

Technique	Recommended Specifications
Special Habitat Features	- Ground water seeps in excavated areas may provide salt licks. - Human disturbance after site abandonment must be minimized.
Additional Benefits	- Suitable habitat for this species will provide good quality habitat for some small mammals (red squirrels), some furbearers (marten and fisher), climax-associated songbirds. Development of caribou habitat may not be possible within the normal time-frame of most developments.

Table 7. Reclamation objectives for mule deer in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Gently-sloping to steep terrain is preferred and provides escape cover. Rough terrain also preferred for escape cover. South and west facing slopes provide critical winter range. - Free-dumping of overburden would provide complex above-grade topography as well as a variety of slopes and aspects. - Recontour smooth slopes to form rolling terrain through creation of depressions on lift terraces or random free-dumping on slopes. - Shape overburden and tailings sand stockpiles to provide large south and west aspects, rough terrain and moderate to steep slopes.
Watershed Re-establishment	- No specific water requirements but valley complexes provide good balance of food and cover.
Revegetation	- Provide an intermix of grasslands, shrublands, deciduous forest, and coniferous forest,. - Locate grassland communities adjacent to forest or shrub cover and do not exceed 200 m in width; south and west aspects preferred. - Establish shrublands in moist depressional sites or riparian areas; include willows, dwarf birch, and green alder in plantings. - Plant deciduous forest communities on east, west and some northern aspects; use aspen as the dominant tree species and an understory of saskatoon, choke cherry, red osier dogwood, rose, willow and snowberry. - Establish conifer forests on northeastern to southeastern aspects in proximity to the proposed winter range (in order to eventually provide thermal protection from the prevailing west and northwest winds). Use white spruce and balsam fir as predominant tree species and understory as described for deciduous forest. Mature canopy should provide 75% cover. - Habitat blocks for thermal cover and hiding cover should be 1-5 ha in size. Open interstitial areas between tree and shrub habitat units should not exceed 200 m. - Where possible, maintain 1-5 ha blocks of undisturbed conifer forest for thermal cover in proximity to south and west facing winter range areas.

..... Table 7 continued

Table 7 concluded.

Technique	Recommended Specifications
Special Habitat Features	- If excavations expose saline ground water seeps, develop as an artificial mineral lick.
Additional Benefits	- The interspersion of forest, shrub and grasslands communities will eventually provide habitat for small mammals (chipmunks, squirrels, snowshoe hares), furbearers (weasels, fox, coyote), other ungulates, songbirds, upland gamebirds and some raptors.

Table 8. Reclamation objectives for moose in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Flat to gently-sloping terrain provides major habitats. - Rolling terrain with gentle slopes (i.e., 5%) will provide diverse conditions for plant community development. - Recontour or construct drainage channels to form flat bottomed valleys with broad mesic flood plains (compatible with beaver). - Hilltops planted to shrubs can provide winter browse with minimal snow cover.
Watershed Re-establishment	- Waterbodies and watercourses are not essential features but will improve habitat and provide escape from insect harassment. - Watercourse habitats should include large riparian areas which are important for browse production and, possibly, calving. - Waterbodies should contain large shallow areas (water depth < 1 m) with amended substrates (topsoil and mulches) to promote establishment of aquatic emergents. - Develop mesic to hydric low areas adjacent to waterbodies to promote riparian tree and shrub growth.
Revegetation	- Revegetation should produce an interspersion of shrublands, deciduous forest, mixed-woods, conifer forests and muskeg forests. - Shrublands and muskeg should be developed in mesic to hydric sites, particularly in the vicinity of waterbodies and watercourses. Shrub plantings should be predominantly willows. - Deciduous and mixedwood forests should be located on better drained sites and northwest, north and east aspects. Tree plantings should include aspen, with lesser amounts of white birch, white spruce and black spruce. Shrub plantings should include willow, saskatoon, dwarf birch, red-osier dogwood, choke cherry, pin cherry, and low-bush cranberry. - Conifer forest plantings will eventually provide thermal cover and should be predominantly white and black spruce with shrub understories similar to those for deciduous/mixedwood forests. Mature canopy should provide 75% cover to be effective for thermal protection. - Forest habitat blocks should be a minimum of 100-150 m wide with interstitial open areas (shrublands and grasslands) not exceeding widths of 100-200 m.

..... Table 8 continued

Table 8 concluded.

Technique	Recommended Specifications
	- Maintenance of undisturbed blocks of forest cover (2-5 ha) will provide some suitable cover for moose and will promote use of the reclaimed site.
Special Habitat Features	- Saline ground water seeps can be developed as artificial mineral licks.
Additional Benefits	- Reclamation of moose habitat will also provide habitat for small herbivores (e.g., snowshoe hares), upland gamebirds, and songbirds. Highly compatible reclamation requirements with beaver.

Table 9 . Reclamation objectives for sharp-tailed grouse in the Boreal Forest biome.

Technique	Recommended Specifications
Topographic Modification	- Flat to gently-sloping terrain provides major habitats. - Rolling terrain with gentle slopes will provide diverse conditions for plant development. - Use combination of free-dumping and recontouring on flat or gently-sloped areas to provide rolling terrain. - In flat areas intended as grassland sites, small, dry elevated mounds (e.g., free-dumped tailings sand or overburden) should be created to provide artificial dancing arenas. Based on the average spacing of natural dancing arenas, provide at least 1.5 km^2 of grassland habitat for each dancing arena.
Watershed Re-establishment	- No specific requirements
Revegetation	- Optimal habitat provided by a community mosaic predominated by grasslands, low shrublands and deciduous forest. Grass-shrubland transitional areas are most important. - Low profile grasses such as fescues should be planted in the dancing arenas. - Grassland areas should be established around each dancing arena such that the grassland area occupies at least 69% of the 1.5 km^2 area.. Tall grass species such as wheatgrasses, barley and rye are preferred. - Low shrubland and deciduous forest should occupy much of the remaining area with plantings consisting of trees such as aspen or balsam poplar and shrubs such as choke cherry, bearberry, saskatoon, pin cherry, buffalo-berry, willow and silverberry. - Dry bogs comprised mainly of Labrador tea, bog cranberry, black spruce, and mosses should be created in mesic bottomlands.
Special Habitat Features	- No special features other than dancing arenas (see above) are known. - Sound recordings of dancing males have been used successfully near appropriate dancing sites to attract some sharp-tailed grouse to artificial dancing arenas on reclaimed sites.
Additional Benefits	- Sharp-tailed grouse is the only key species that is representative of grassland-shrubland habitats in the Boreal Forest biome. Reclamation of sharp-tailed grouse habitats will therefore be useful in providing grassland and shrub communities for some small mammals, songbirds and small ungulates (e.g., deer).

Table 10. Species of plants with known suitability for reclamation and used by wildlife for food or cover in the Boreal Forest biome (Sources: Watson et al. 1980; P.F.R.A. n.d.; J. Stelfox, pers. comm.).

	Wildlife	Ungulates	Bighorn Sheep	Deer	Mule Deer	White tailed Deer	Elk	Moose	Bears	Furbearers	Beavers	Rabbits, Hares	Red Squirrels	Chipmunks, Pikas	Birds	Game Birds	Comments
GRASSES																	
Bluegrass, Canada				F													palatable to livestock
Bluegrass, Kentucky			F		F		F	F									palatable to livestock
Bluejoint																	moderately palatable to livestock
Barley, Foxtail					F											F, C	unpalatable seeds but palatable before flowering
Brome, Awnless		F															palatable to livestock
Canary Grass, Reed					F, C											F, C	low palatability to livestock
Fescue			F		F		F	F									
Fescue, Red			F	F													highly palatable to livestock
Fescue, Sheep			F	F	F											F, C	low to moderate palatability to livestock
Foxtail, Creeping				F			F										moderately to highly palatable to livestock
Hair Grass, Tufted					F				F							F	palatable to livestock
Needle Grass					F											F	palatable to livestock before going to seed
Orchard Grass	F																highly palatable to livestock
Redtop	F, C			F													low palatability to livestock
Ryegrass																	palatable to livestock
Sedge			F		F	F	F	F									
Timothy		F	F	F			F								F		palatable to livestock
Wheat Grass, Crested			F		F		F										moderately to highly palatable to livestock
Wheat Grass, Pubescent			F				F	F									palatable to livestock
Wheat Grass, Slender			F	F			F	F									moderately palatable to livestock
Wheat Grass, Streambank																	low palatability to livestock
Wild Rye, Hairy																	not palatable where palatable species are available
Wild Rye, Russian				F													highly palatable to livestock
FORBS																	
Clover, Alsike					F		F					F				F	palatable to livestock
Clover, Red					F		F					F				F, C	highly palatable to livestock
Clover, White			F		F		F		F			F				F	highly palatable
Hedysarum		F					F		F					F			palatable to livestock, H. mackenzie poisonous
Loco-weed, Late Yellow																	poisonous to livestock
Medick			F		F												palatable to livestock
Milk Vetch, Cicer					F		F	F									palatable to livestock
Pea Vine	F		F	F	F	F	F	F				F					
Sainfoin	F																palatable to livestock
Sweet Clover			F		F		F									F, C	palatable to livestock
Trefoil, Birdsfoot																	highly palatable to livestock
Vetch, Wild	F		F	F	F	F	F	F								F	highly palatable to livestock
Willow herb					F			F						F			
TREES AND SHRUBS																	
Alder, Green					F			F									
Alder, River					F		F										
Bearberry, Alpine			F						F						F		
Bearberry, Common			F		F				F						F	F	
Birch, Paper							F	F									moderately palatable
Buffalo-berry, Canadian				F			F		F								low palatability
Cherry, Choke		F	F	F	F	F	F								F	F	
Cinquefoil, Shrubby					F		F										low palatability
Dogwood	C		F	F	F, C	F	F	F				F			F	F	
Juniper, Creeping					F												
Juniper, Ground	not eaten														F		
Maple, Manitoba	avoided																low palatability
Pine, Lodgepole			F		F		F			F		F					
Poplar, Aspen				F	F		F	F									palatable to livestock
Poplar, Balsam		F						F			F						
Raspberry, Wild Red	F	F		F	F	F	F	F									
Rose, Common Wild		F	F	F	F, C	F	F									F, C	highly palatable
Rose, Prickly			F	F	F	F									F	F	
Saskatoon			F	F	F, C	F	F	F				F			F, C	F	moderately to highly palatable
Snowberry				F	F	F	F								F		
Spruce, White					C	C	C	C				F	F				
Tamarack	not eaten		F												F	F	
Willow				F, C	F, C	F, C	F	F									
Willow, Bebb				F				F				F					
Willow, Grayleaf								F									
Willow, Scouler					F, C			F								F, C	

F = FOOD C = COVER

8.0 ASPEN PARKLAND BIOME

8.1 BIOME DESCRIPTION

This biome is comprised entirely of the Aspen Parkland habitat region/ecoregion (Figure 1) as described by Knapik and Westworth (1984) and Strong and Leggat (1981). It forms a transition zone between the forest and grassland regions of the three provinces.

The distinguishing feature of this biome is a vegetation mosaic of grassland and aspen clones developed on generally subdued topography, with admixtures of spruce in poorly drained situations. Shrublands are a major community type on north-facing slopes and in ravines. Much of the area has been converted to cropland or is used for cattle grazing.

8.2 KEY WILDLIFE SPECIES

Key species selected for this biome include beaver and muskrat as representatives of aquatic species, mule deer and sharp-tailed grouse representing species using forest edge, shrub and grassland communities, and red squirrel representing species requiring conifer cover. Specific habitat requirements of these species are discussed in detail in Volume II.

8.3 INDUSTRIAL ACTIVITIES IN THE ASPEN PARKLAND BIOME

Industrial activities in the Aspen Parkland biome include in-situ oil sand extraction, conventional oil and gas activities, sour gas extraction facilities, open pit coal mines, borrow pits and linear ROWs for pipelines and seismic lines. Diverse, rolling terrain, referred to a 'knob and kettle' topography is common throughout much of this biome and provides an abundance of terrestrial and aquatic wildlife habitats as a result of the diversity of elevations, slope-aspects and soil types. Creation of moderate-sized material stockpiles and basins can therefore be compatible with the surrounding landscape.

Coal mines for electric power generation in the Lake Wabumun area (e.g., the Whitewood, Highvale and proposed Genesee mines) are one of the largest industrial developments in the biome. A number of small coal mines are also active throughout this biome. Mining practices in this area generally involve the stripping and storage of the topsoil and removal of the overburden material (e.g., mineral soils) to expose the coal bearing seams. Overburden is usually stored in large stockpiles but has been free dumped at some sites (e.g., portions of the Whitewood mine site). Dragline operations on established mines often work sequentially through a site, depositing the overburden material from a new mine area directly into the last completed mine area. Following recontouring to flat or gently-sloping terrain and replacement of the topsoil, reclamation can proceed behind the mining operation. If a sequential operation is not employed, the exhausted mine pit is backfilled with overburden from adjacent mines and reclaimed as described above. Because of the agricultural land uses in the aspen-parkland biome, most active mine areas will eventually be restored for agricultural use (e.g., the Whitewood mine site; P. Lulman, pers. comm.). However, problem areas within these sites such as areas of poor quality soil, rough terrain and industrial ponds can be adapted for wildlife habitat reclamation more easily than for agricultural end uses..

In-situ oil sand extraction, conventional oil and gas extraction, and sour gas facilities will result in the removal of forest cover from the project site and, possibly, removal and temporary stockpiling of top soil. Few or no below-grade excavations are necessary. Reclamation of these sites within the forested portion of the biome may consider agricultural end uses but the small size of these sites limits the practicality of this option. Wildlife habitat reclamation is feasible on these sites and could be implemented at a lower cost than agricultural reclamation because of a reduced need for recontouring to a flat or gently-rolling terrain and drainage.

Borrow pits within this biome are generally of a similar design to that already described for the boreal forest biome. Shapes are generally rectangular to square with depths of up to several meters. The small size of borrow pits makes them ideal for reclamation to either terrestrial or aquatic wildlife habitat.

Linear ROWs will involve the removal of forest cover and, possibly, some shallow excavations (e.g., pipelines). As described in Section 7.3, characteristics of ROWs restrict the types of wildlife habitat reclamation that can be implemented, particularly in terms of the physical conditions on the site.

8.4 Wildlife Habitat Reclamation Techniques for the Aspen Parkland Biome

Only one example of a wildlife habitat reclamation program was identified in the Aspen Parkland biome. Beginning in 1976, an older portion of the Whitewood mine site near Lake Wabumum was designated as a wildlife reclamation area and has been the subject of an ongoing study by TransAlta Utilities, the Canadian Wildlife Service and the Stony Plain Fish and Game Association (P. Lulman, pers. comm.). The area is comprised of rough 'knob and kettle' terrain reflecting the free-dumping of overburden material on the site. Establishment of trees and shrubs through a revegetation program and natural invasion has greatly improved values for wildlife on the area (J. Stelfox, pers. comm.). Mule deer, white-tailed deer, moose, coyotes, ruffed grouse, sharp-tailed grouse and a variety of passerines have been observed to utilize the area (Scheideman and Stelfox 1981). Planting of trees and shrubs and natural invasion of woody plants (particularly aspen) has been most successful in depressional sites. Clump planting of conifers (white spruce) with deciduous tree and shrub species has been successful in providing food and cover for deer and grouse (J. Stelfox, pers. comm.).

No other examples of wildlife habitat reclamation or plans for wildlife habitat reclamation are known for the Aspen Parkland biome.

8.5 Recommended Reclamation Techniques for Key Species

Specific techniques for reclaiming habitat for each of the key species in the Aspen Parkland biome are summarized in Tables 11-15. Modifications to the general techniques described in Section 6 are provided, where possible, to better adapt these techniques to conditions within this biome. Potential wildlife uses of grasses, forbs, shrubs and trees of known commercial propagation and suited to conditions in the Aspen Parkland biome are summarized in Table 16.

Table 11. Reclamation objectives for red squirrel in the Aspen Parkland biome.

Technique	Recommended Specifications
Topographic Modification	- Distribution is related primarily to vegetation cover rather than topography per se.
Watershed Re-establishment	- No specific requirements. - Some poorly drained sites should be maintained or created to provide suitable areas for development of black spruce forests.
Revegetation	- Mature white spruce or mixed white and black spruce forests provide optimum habitat; because red squirrels rely on cones of these tree species for food, animal responses to revegetation will probably not occur until the white and black spruce communities reach cone bearing age (e.g, 10-30 years). - White spruce forests should be located on north and east facing aspects or on flat to gently-sloping areas. Tree plantings should be predominantly white spruce but some aspen or paper birch could be included for faster-growing cover. Understory should include some berry-producing shrubs, hazelnut, bearberry, and rose (to provide supplementary food supplies). - Other forest communities such as jack pine forests and mixedwoods should also be interspersed with white spruce forests in order to provide alternative food sources in years of cone crop failures. - Maintenance of islands of mature spruce forest will provide some immediate cover and food supplies. - Habitat units should be a minimum of 0.25-0.7 ha (based on average territory sizes).
Special Habitat Features	- If islands of mature spruce forest are maintained, preserve large middens (accumulations of shredded cones), where possible.
Additional Benefits	- Reclamation or maintenance of suitable habitat for red squirrels will also provide areas of thermal cover for ungulates, year-round or seasonal habitat for spruce grouse, and songbirds, and a prey base for some mustelids. Maintenance of mature forest units will also provide sources of seeds for natural invasion into the reclaimed area.

Table 12. Reclamation objectives for beaver in the Aspen Parkland biome.

Technique	Recommended Specifications
Topographic Modification	- Only effective within 245 m of a permanent waterbody or watercourse (maximum foraging range of beaver from water) and most effective within 30 m. - Recontouring should focus on the creation of smooth gently-sloping (<25%) or rolling terrain to permit access by the animals and movement of food materials. - Creation of a 'knob and kettle' terrain through free dumping or specialized contouring of spoil piles is highly compatible with regional landscape and will provide good aquatic and terrestrial habitat for beaver. - Recontouring or creation of drainage channels should provide shallow gradients (<5-7%) with well-defined banks and broad mesic flood plains (e.g., 45 m wide).
Watershed Re-establishment	- Minimum area of 0.8 km of stream or 1.3 km^2 of lake/marshland habitat is required. - Watercourse design should include a low gradient (5-7% slope is optimum), a meandering channel, well-defined banks (to permit the construction of stable dams) and clay soils (to ensure water retention). Water flows should be sufficient to maintain water depths of 0.9-1.5 m behind a dam. - Waterbodies should include irregular shorelines, clay substrates and water depths of 0.9-1.5 m. If the outlet is damable, beaver will modify water depths to preferred levels.
Revegetation	- A willow-aspen community is most desirable within 30 m and up to 245 m from water. Both species provide a good source of food and building materials. Willows also help stabilize watercourse banks. - Willows are best established in riparian and other hydric sites (e.g., bottom depressions) using large numbers of cuttings (dipped in root hormone). - Balsam poplar, alder, paper birch, dwarf birch are also suitable woody species for revegetation. - Water lilies and cattails are a preferred food and can be planted in reclaimed waterbodies. - Conifers are not utilized and can be planted in areas where beaver activity is discouraged.

.....Table 12 continued

Table 12 concluded.

Technique	Recommended Specifications
Special Habitat Features	- Because beaver rely on woody plants for food, they may retard re-establishment of trees and shrubs. However, they are a useful key species because of their ability to regulate water levels and create water impoundments which, in turn, are beneficial to a large number of mammals and birds. - Beaver can be maintained on a site by providing food and construction materials, particularly during the late summer and fall when food caching and construction are at a peak. Freshly cut willows and aspen from adjacent natural areas will be utilized by beaver if provided close to the waterbody or watercourse.
Additional Benefits	- Reclamation of beaver habitat will provide habitat for diving and dabbling waterfowl, semi-aquatic mammals such as mink and otter and improved water supplies for terrestrial wildlife. Waterlilies may also be used by moose. Riparian shrub and tree communities will provide woody browse for ungulates and snowshoe hares.

Table 13. Reclamation objectives for muskrat in the Aspen Parkland biome.

Technique	Recommended Specifications
Topographic Modification	- Because of the predominantly aquatic habits of this species, topographic modification is primarily applicable to the design of waterbodies and watercourses (see below).
Watershed Establishment	- Based on home range sizes, waterbodies must provide a minimum of 200 m^2 of marshland habitat. - Overwintering water depths must exceed 0.7 m. - Watercourse habitats should have shallow gradients (3-5%), low water velocities, convoluted channels, and some well-defined clay banks (for construction of bank dens). - Waterbodies should have irregular shorelines and contain large areas (50-60% of pond) with water depths of 0.5-1.5 m to promote development of emergent aquatic vegetation. - Bottom substrates in waterbodies should be capped with a topsoil and hay mulch amendment to promote emergent growth. - Water levels in wetlands or ponds should be severely reduced during the summer period once every 5-7 years to maintain vigorous growths of aquatic plants.
Revegetation	- Two vegetation communities should be established: aquatic plants and riparian shrub. - Aquatic plants should include emergent plants such as bulrushes, cattails and reeds and submergent/floating plants such as duckweed or pondweed. Establish through direct transfer (of rhizomes and live plants, respectively), innoculation of waterbody with bottom substrates from natural wetlands or direct seeding (collections of natural seed will be required). These plants provide an essential food source and construction material. Emergent plants should eventually occupy 50-60% of the pond area. - Establish riparian shrub communities along streambanks and shorelines for stabilization using numerous fresh cuttings (dipped in rooting hormone) from local willows.
Special Habitat Features	- Not applicable
Additional Benefits	- Reclamation for muskrats will provide good habitat for dabbling waterfowl, shorebirds, marsh-associated songbirds, semi-aquatic mammals and amphibians as well as a water source for terrestrial wildlife. Riparian community development will benefit ungulates and small mammals (e.g., snowshoe hares).

Table 14. Reclamation objectives for mule deer in the Aspen Parkland biome.

Technique	Recommended Specifications
Topographic Modification	- Gently-sloping to steep terrain is preferred and provides escape cover. Rough terrain is also preferred for escape cover. South and west facing slopes provide critical winter range. - Free-dumping of overburden would provide complex above-grade topography as well as a variety of slopes and aspects. - Recontour smooth slopes to form rolling terrain through creation of depressions on lift terraces or random free-dumping on slopes. - Shape overburden and tailings sand stockpiles to provide large south and west aspects, rough terrain and moderate to steep slopes.
Watershed Re-establishment	- No specific water requirements but valley complexes provide good balance of food and cover.
Revegetation	- Provide an intermix of grasslands, shrublands, deciduous forest, and coniferous forest. - Locate grassland communities adjacent to forest or shrub cover and do not exceed 200 m in width; south and west aspects preferred. - Establish shrublands in moist depressional sites or riparian areas; include willow, dwarf birch, red-osier dogwood, wood rose and green alder in plantings. - Plant deciduous forest communities on east, west and some northern aspects; use aspen as the dominant tree species and an understory of saskatoon, choke cherry, red-osier dogwood, rose, willow and snowberry. - Establish conifer forests on northeastern to southeastern aspects in proximity to the proposed winter range (in order to eventually provide thermal cover). Use white spruce and balsam fir as predominant tree species and understory as described for deciduous forest. Mature forest canopy should provide 75% closure. - Habitat blocks for thermal cover and hiding cover should be 1-5 ha in size. Open interstitial areas between tree and shrub habitat units should not exceed 200 m. - Where possible, maintain 1-2 ha blocks of undisturbed conifer forest for thermal cover in proximity to south and west facing winter range areas.

..... Table 14 continued

Table 14 concluded.

Technique	Recommended Specifications
Additional Benefits	- The interspersion of forest, shrub and grassland communities will eventually provide habitat for small mammals (chipmunks, squirrels, snowshoe hares), furbearers (weasels, fox, coyote), other ungulates, songbirds, upland gamebirds and some raptors.

Table 15. Reclamation objectives for sharp-tailed grouse in the Aspen Parkland biome.

Technique	Recommended Specifications
Topographic Modification	- Flat to gently-sloping terrain provides major habitats. - Rolling terrain with gentle slopes will provide diverse conditions for plant community development. - Use combination of free-dumping and recontouring on flat or gently-sloped areas to provide rolling terrain. - In flat areas intended as grassland sites, small, dry elevated mounds (e.g., free-dumped tailings sand or overburden) should be created to provide artificial dancing arenas. Based on the average spacing of natural dancing arenas, one marsh should be provided within each 1.5 km^2 area of grassland sites. - Small depressions ≥ 0.5 ha should also be created that can be revegetated into dry bogs.
Watershed Re-establishment	- No specific requirements
Revegetation	- Optimal habitat is provided by a mosaic of plant communities predominated by grasslands, low shrublands, dry bogs and aspen forest. Grass-shrubland transitional areas are most important. - Grassland areas should be established around each dancing arena such that the grassland area occupies at least 69% of the 1.5 km^2 area. Tall grass species (25 cm minimum) such as wheatgrasses, barley and rye are preferred. Dense grass areas are required for nesting. - Low shrubland, dry or mesic bogland, and aspen forest should occupy much of the remaining area with plantings consisting of aspen and shrubs such as choke cherry, bearberry, saskatoon, pin cherry, buffaloberry, willow and silverberry. In dry or mesic bog habitats, mosses, bog cranberry, Labrador tea and black spruce should dominate the plantings. - Some aspen copses should occur within a 0.8 km radius of the dancing arena (to provide nesting and escape cover).

..... Table 15 continued

Table 15 concluded.

Technique	Recommended Specifications
Special Habitat Features	- No special features other than dancing arenas (see above) are known. - Sound recordings of dancing males have been used successfully near appropriate dancing sites to attract sharp-tailed grouse to artificial dancing arenas on reclaimed sites.
Additional Benefits	- Sharp-tailed grouse is the only key species that is representative of grassland-shrubland habitats in the Aspen Parkland biome. Reclamation of sharp-tailed grouse habitats will therefore be useful in providing grassland and shrub communities for some small mammals, songbirds and small ungulates (e.g., deer).

Table 16. Species of plants with known suitability for reclamation and used by wildlife for food or cover in the Aspen Parkland biome (Sources: Watson et al. 1980; P.F.R.A. n.d.; J. Stelfox, pers. comm.).

	Wildlife	Ungulates	Bighorn Sheep	Deer	Mule Deer	White tailed Deer	Elk	Moose	Mountain Goats	Bears	Furbearers	Beavers	Rabbits, Hares	Red Squirrels	Chipmunks, Pikas	Birds	Game Birds	Comments
Bluegrass, Alpine		F																
Bluegrass, Kentucky			F		F		F	F										highly palatable to livestock
Bluejoint																		palatable to livestock
Barley, Foxtail					F													moderately palatable to livestock
Brome, Awnless		F															F.C	unpalatable seeds but palatable before flowering
Brome, Mountain			F		F		F	F										palatable to livestock
Canary Grass, Reed					F.C													palatable to livestock
Fescue			F		F		F	F									F.C	low palatability to livestock
Fescue, Red																		
Fescue, Sheep					F													highly palatable to livestock
Foxtail, Creeping				F			F										F.C	low to moderate palatability to livestock
Hair Grass, Tufted					F					F								moderately to highly palatable to livestock
June Grass			F		F		F	F									F	palatable to livestock
Needle Grass					F													highly palatable to livestock
Orchard Grass	F																F	palatable to livestock before going to seed
Redtop	F.C																	highly palatable to livestock
Reed Grass, Purple			F															low palatability to livestock
Rice Grass, Indian				F	F													low palatability to livestock
Ryegrass																F	F	palatable to livestock
Sand Grass					F													palatable to livestock
Sedge			F		F		F	F									F	palatable to livestock
Sedge, Ross's																		
Sweetgrass								F										palatable to livestock
Timothy, Mountain		F																low palatability to livestock
Trisetum, Spike					F													palatable to livestock
Wheat Grass, Crested																		highly palatable to livestock
Wheat Grass, Intermediate																		moderately to highly palatable to livestock
Wheat Grass, Pubescent			F				F	F										palatable to livestock
Wheat Grass, Slender			F				F	F										palatable to livestock
Wheat Grass, Streambank																		moderately palatable to livestock
Wheat Grass, Tall																		low palatability to livestock
Wheat Grass, Western	F																	moderately palatable to livestock
Wild Rye, Hairy																		palatable to livestock
Wild Rye, Russian				F														not palatable where palatable species are available
FORBS																		highly palatable to livestock
Clover, Alsike					F													
Clover, Red					F												F	palatable to livestock
Clover, White					F												F.C	highly palatable to livestock
Hedysarum		F	F				F			F							F	highly palatable
Loco weed, Late Yellow																		palatable to livestock, H. mackenzie poisonous
Lupine, Perennial					F													poisonous to livestock
Medick					F												F.C	low palatability to livestock, seeds and pods poisonous
Milk Vetch, Cicer			F		F		F	F										palatable to livestock
Pea Vine	F																	palatable to livestock
Sweet Clover					F													
Trefoil, Birdsfoot																	F.C	palatable to livestock
Vetch, Wild	F				F													highly palatable to livestock
Willow herb					F			F									F	highly palatable to livestock
TREES AND SHRUBS															F			
Alder, Green					F			F										
Alder, River					F		F											
Alder, Sitka					F		avoid	avoid										
Bearberry, Alpine										F								
Bilberry, Common					F					F						F		
Birch, Paper								F								F	F	
Buffalo berry, Canadian				F			F			F								moderately palatable
Cherry, Choke		F		F	F	F	F											low palatability
Cinquefoil, Shrubby			F		F		F									F	F	
Dogwood	C			F	F.C		F	F										low palatability
Dryad, White	unpalatable												F			F	F	
Dryad, Yellow	unpalatable																F	
Elderberry																		
Fir, Alpine				F			F	F						F		F	F	low palatability
Hawthorn				F									F					
Juniper, Creeping					F								F			F	F	
Juniper, Ground	not eaten																	
Maple, Manitoba	avoided															F		
Meadowsweet, White				F			F											low palatability
Pine, Lodgepole					F													
Poplar, Aspen			F	F	F		F	F			F		F					
Poplar, Balsam		F										F						palatable to livestock
Raspberry, Wild Red	F																	
Rose, Common Wild		F			F.C		F											
Rose, Prickly					F												F.C	highly palatable
Saskatoon					F.C	F	F	F								F	F	
Silverberry			F		F								F			F.C	F	moderate to high palatability
Snow Brush	low value			F	F		F.C		F									low palatability
Spruce, White					C		C											
Willow			F		F		F	F					F	F				
Willow, Arctic	F		F															
Willow, Bush				F				F										
Willow, Grayleaf								F					F					
Willow, Scouler					F.C			F									F.C	

F = FOOD C = COVER

9.0 MOUNTAIN AND FOOTHILL BIOMES

9.1 BIOME DESCRIPTION

The cordilleran zone in the prairie provinces consists of the Boreal Upland, Montane, Subalpine and Alpine wildlife habitat regions/ecoregions as delineated by Knapik and Westworth (1984) and Strong and Leggat (1981). Together these comprise the Foothill and Mountain biomes (Figure 1), which are here treated together due to their spatial association across the Boreal Uplands and Montane regions.

The Boreal Uplands habitat region features closed canopy coniferous forest developed on both foothill and mountain topography, and on the outlying Swan Hills. Lodgepole pine forest predominates on well-drained to imperfectly drained sites, with succession toward white and black spruce; depressional areas are covered by black spruce and birch/sedge vegetation types. The Mountain biome is restricted to the foothills and major valleys of the Rockies, and is distinguished by the occurrence of Douglas fir and/or limber pine which occur on well- to moderately well-drained soils and on sandstone outcrops, respectively. Dry sites are characterized by grassland vegetation, moist and cool sites by aspen and lodgepole pine with invasion by white spruce and Douglas fir. Lodgepole pine forests also dominates the lower zone of the Subalpine habitat region, but these give way to spruce-fir forests at higher elevations and to grasslands on steep south-facing slopes. The Alpine habitat region, defined as the zone above altitudinal forest-line, is characterized by low-growing vegetation and clumps of stunted trees.

The Mountain and Foothill biomes are critically important for watershed protection, and current management is geared toward this. Other uses include forestry, mining, livestock grazing, recreation and wildlife habitat protection. The warm valleys of the Montane region and the grassland slopes of the Subalpine region are especially important as ungulate winter habitat.

9.2 KEY WILDLIFE SPECIES

Key species selected for these biomes include two wetland species (beaver and muskrat) and eight species variously associated with grasslands, shrublands, forest edges and forests, and alpine tundra (snowshoe hare, caribou, moose, elk, mountain goat, bighorn sheep, spruce grouse and white-tailed ptarmigan). Habitat requirements of these species are reviewed in detail in Volume II.

9.3 INDUSTRIAL ACTIVITIES IN THE MOUNTAIN AND FOOTHILL BIOMES

Industrial activities with reclamation requirements in the Mountain and Foothill biomes include open pit and strip mining operations, rock quarries, oil and gas extraction and exploration, sour gas processing, recreational developments (primarily ski resorts), borrow pits and linear ROW such as pipelines, transmission lines and seismic lines. Recent expansions of the Trans-Canada Highway, Canadian Pacific rail line and the Canadian National rail line have also required reclamation of disturbed areas. Although forestry is presently recognized as the primary land use for reclaimed areas in the Foothill biome, there are many opportunities for reclamation of wildlife habitat in the Mountain biome as well as in selected areas of the Foothill biome. In many forestry reclamation areas, wildlife habitat can be incorporated as a secondary land use, with benefits to both the forest industry and wildlife and possible economic benefits to industry through reduced reclamation costs. Indeed, wildlife habitat reclamation is ongoing or has been incorporated into reclamation plans at a number of coal mines (the Cardinal River, Gregg River, Coal Valley, Obed, and Smokey River Coal mines and the proposed McLeod River project) and in several disturbed sites within Banff and Jasper National Parks.

Mining is one of the largest industries within the Mountain and Foothill biomes and, because of the types of land disturbances associated with mining procedures, the mining industry is one of the most actively-involved groups in reclamation planning and research. Mine activities in these biomes are usually open pit or strip mines and, by necessity, must move topsoil and large quantities of overburden to extract the coal or ore. Because of the recently glaciated nature of some areas within these biomes, topsoil layers are often thin and difficult to salvage separately from the underlying mineral soils. Temporary storage piles for topsoil and spoil piles are common products of most mines in the area. As a result of the rugged terrain throughout the Mountain and Foothill biomes, the geological formations and the mining methods, many mines also produce one to several highwalls during the mining process. Current regulations for forestry end uses have required that most of the mine landscape be recontoured to provide moderate slopes with smooth contours. Most end pits are also required to be backfilled.

The location of surface mined pits is determined by the economic cut off strip ratio; that is the amount of rock and soil overburden which can be economically removed to expose a known volume of the resource. The sides of the pit, or highwalls, are left as steep as safely possible to minimize the amount of overburden which must be handled. External dumps and pit backfills are designed to minimize overburden haulage costs. In most cases, current reclamation requirements call for highwalls and final dump slopes to be recontoured to a maximum of 27 degrees (the biological angle of repose). Such recontouring currently accounts for a major portion of the reclamation costs at most sites, yet from a wildlife perspective, may actually reduce the value of reclaimed areas for some wildlife. For example, highwalls add structural and topographic diversity to wildlife habitat and provide specialized habitat components for some species (e.g., raptor nesting sites, potential talus formations). If properly reclaimed, they can also provide aesthetic benefits. Revegetation in the Mountain biome and, to a lesser degree, in the Foothill biome is restricted by harsh climatic conditions, limited topsoil supplies and a short growing season. Despite these limitations, the Mountain and Foothill biomes offer wide scope for habitat rehabilitation. Land reshaping, water impoundment and management, watershed protection, and initial establishment of primary successional species (e.g., grasses and legumes) along with localized plantings of secondary successional vegetation types (low shrubs, aspen and lodgepole pine) are feasible with existing technologies. Borrow pits and rock quarries present similar reclamation opportunities and problems to many of the mine sites within the Mountain and Foothill biomes.

Oil and gas exploration and extraction occurs throughout some areas of the Mountain and all of the Foothill biomes. Pipelines and seismic lines are also common in the Foothill biome. Recent increases in the world price for elemental sulphur has resulted in increased numbers of facilities for processing sour gas. All of these activities will involve clearing of existing forest cover and, possibly, some removal and stockpiling of topsoil. None of these activities require large excavations, hence topographic changes will be minimal. Some oil and gas extraction facilities and sour gas processing plants will require storage lagoons for various purposes which may be adaptable for wildlife habitat.

9.4 WILDLIFE HABITAT RECLAMATION TECHNIQUES FOR THE MOUNTAIN AND FOOTHILL BIOMES

Much of the current information on wildlife habitat reclamation in the prairie provinces is derived from studies in the Mountain and Foothill biomes. However, because most of the wildlife habitat reclamation projects are recent and few quantitative monitoring studies have been conducted, the potential of these techniques to restore or replace wildlife habitat is unknown (Green et al. 1985a). Nevertheless, because much of the Mountain and Foothill biomes is currently covered by mature conifer forest with a low capability for many types of wildlife, establishment of early seral communities on reclaimed sites has a high potential for improving wildlife capability.

9.4.1 Topographic Modification

Almost none of the wildlife reclamation programs in the Mountain and Foothill biomes have attempted to modify existing or planned reclamation terrain for wildlife. The only known examples of topographic modification are in Banff National Park. One example involved the alteration of the final topography of a landfill site to provide better wildlife access to the reclaimed area as well as the construction of an artificial draw and adjacent berm to provide elk with a visually-protected entry to the central portion of the site (G. Harrison, pers. comm.). The second example, a recently completed borrow pit, is one of the few reclamation projects in the prairie provinces that was specifically pre-planned and constructed for wildlife. The borrow pit was divided into seven distinct cells separated by forest stringers and raised berms. Sizes of the cells and widths of the openings into each cell were based on known line-of-site distances for elk (Thomas 1979c). Several coal mines (Cardinal River Coal, Gregg River, Crowsnest Resources,and Westar mines) may retain highwalls and develop them as habitat for mountain goats, mountain sheep and raptors. The Cardinal River Coal and Coal Valley mines may also recontour some overburden and spoil piles for wildlife.

9.4.2 Watershed Re-establishment

Watershed re-establishment in the Mountain and Foothill biomes has involved watercourse reclamation and creation, creation of lakes, and creation of wetlands.

Stream reclamation has been undertaken in several industry and government projects including the Trans-Canada Highway expansion, the Hanlan-Robb project of Gulf Canada Resources, the Coal Valley mine, the Fording Coal mine and a joint project of the Alberta Fish and Wildlife Division and Alberta Transportation along the Crowsnest River. Although none of these projects are more than 3-4 years old, short-term results suggest that construction of overhanging banks, establishment of riparian vegetation for bank stabilization and construction of meandering channels with artificial cobble riffles and pools are all important techniques for providing habitat for some wildlife and fish.

No examples of reclamation programs to intentionally create lakes and ponds are known. Lakes are present in the old mine spoil areas at Coal Valley (R. Ferster, pers. comm.) but wildlife use is limited because of the steep bottom slopes and outslopes around the pond, the lack of shallow water areas, and poor soil composition with the resulting effects on the development and productivity of aquatic and terrestrial vegetation communities. Reclamation plans at the Cardinal River and Coal Valley mines may both include the enhancement of their end pits for wildlife and fisheries habitat. At the Obed mine, several large borrow pits may be converted for waterfowl use by constructing shallow littoral zones and nesting islands and establishing emergent vegetation.

Wetlands have or may be created as part of the reclamation programs in several government and industry projects in the Mountain and Foothill biomes. Several small wetlands were created as part of a reclamation program by Parks Canada for a borrow pit in Banff National Park. All of these wetlands were created by excavating below the ground water table. A gravel nesting island was also built within one of these wetlands. Topsoil amendments will be added to the bottom substrates of the wetlands as well as to the nesting island. Settling ponds at the Obed mine may also be converted to wetlands.

9.4.3 Revegetation

Although a substantial amount of reclamation research has been conducted by industry and government in the Mountain and Foothill biomes, much of this work has focused on the refinement of methods to establish and propagate vegetation for these biomes. Because of the emphasis of this research on single species, only a minor amount of research has involved the development of techniques for the establishment of vegetation communities. Revegetation for wildlife habitat has not been incorporated into many of the existing mine reclamation plans because of the current emphasis on forestry end uses.

Reclamation of vegetation communities has been incorporated into reclamation programs or plans at the Cardinal River, Gregg River and Westar mines and the proposed McLeod River project, and in habitat reclamation projects by Parks Canada. Potential locations for vegetation communities on above-grade mine features, flat areas and below-grade features are discussed in detail in Section 6.3.3. Because of the expense of establishing vegetation communities, some reclamation plans have focused on the establishment of discrete vegetation islands or units separated by grassland areas. Feasible methods of establishing vegetation islands in the Mountain and Foothill biomes include shrub clusters, topsoil islands, natural vegetation islands, forest stringers and hedgerows. Once established, these vegetation units provide visual and thermal cover and food for wildlife as well as a seed source for natural invasion into the interstitial grassland areas. Planting of additional vegetation community units in the interstitial areas can also help promote community development.

Selection of appropriate vegetation communities and plant species for these communities is dependent on a number of site-specific variables such as climate, soil types, topography, water regimes, and the key wildlife species. Potential plant species and vegetation communities for the Mountain and Foothill biomes are discussed below.

9.4.4 Special Habitat Features

Reclamation or creation of special habitat features such as highwalls, talus slopes, mineral licks, rock piles, and snags have not been incorporated into many of the wildlife reclamation programs in the Mountain and Foothill biomes. Highwalls at the Cardinal River, Coal Valley and Westar mines may be developed for use by mountain goats or bighorn sheep. Raptor nesting sites also may be created on these highwalls. Although no examples of highwall enhancement have been constructed in the prairie provinces, highwalls have been successfully reclaimed for wildlife in several reclamation programs in the United States. The wildlife habitat reclamation program at the Westar mine also includes the placement of snags for raptor use and rock piles for use by small mammals.

9.5 RECOMMENDED RECLAMATION TECHNIQUES FOR KEY SPECIES

Specific techniques and recommendations for reclaiming habitat for each of the key species are summarized in Tables 17-26. Modifications to the general techniques described in Section 6 are provided, where possible, to better adapt these techniques to the conditions of the Mountain and Foothill biomes. Potential wildlife use of grasses, forbs, shrubs and trees of known commercial propagation and suited to conditions in these biomes are summarized in Table 27.

Table 17. Reclamation objectives for snowshoe hare in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Make greatest use of valleys and lower slopes but distribution is probably controlled by vegetation cover rather than by topography per se. - Creation of depressional or low-lying areas with moderate to poor drainage that are suitable for development of riparian shrub communities will promote establishment of suitable food and cover for snowshoe hares.
Watershed Re-establishment	- No specific water requirements; however, drainage plan should ensure that some areas remain moderately to poorly drained in order to promote establishment of riparian shrub communities.
Revegetation	- Vegetation communities should include conifer forests, aspen forest, spruce bogs and shrub thickets. - The key habitat feature in all of these communities is the development of a dense shrub layer. - Shrub layers should preferably be comprised of at least several species including alder, willow, dwarf birch, rose, high-bush cranberry, raspberry, red-osier dogwood and hazelnut. - Conifer forest habitats should be comprised primarily of (i) white spruce and/or black spruce, (ii) Douglas fir or (iii) lodgepole pine with dense shrub understories. - Aspen forest communities should be composed predominantly of aspen but can include lesser amounts of paper birch and white spruce. The shrub understory should include at least several of the species described above. - Maintenance of islands of natural conifer or deciduous forest will provide cover and some food and will permit snowshoe hares to utilize a larger amount of the reclamation site more rapidly. - Information is lacking on habitat unit sizes but home ranges vary from 7-14 ha suggesting that habitat units of this size would be more than adequate. Open shrub or herb communities between the forest or shrub habitat units should not exceed widths of 400 m.

.... Table 17 continued

Table 17 concluded.

Technique	Recommended Specifications
Special Features	- No specific information.
Additional Benefits	- Development of snowshoe hare habitat on reclamation sites will also provide habitat for ungulates such as moose and deer (food and cover), furbearers such as fox, lynx and wolves, other small mammals including weasels, ground-dwelling birds, and upland game birds.

Table 18. Reclamation objectives for beaver in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Only effective within 245 m of a permanent waterbody or watercourse (maximum foraging range of beaver from water) and most effective within 30 m. - Recontouring should focus on the creation of smooth gently-sloping (<25%) or rolling terrain to permit access by the animals and movement of food materials. - Creation of a 'knob and kettle' terrain through free dumping or specialized contouring of spoil piles is highly compatible with regional landscape and will provide good aquatic and terrestrial habitat for beaver. - Recontouring or creation of drainage channels should provide shallow gradients (<5-7%) with well-defined banks and broad mesic flood plains (e.g., 45 m wide). - Streambank substrate should contain predominantly clay material to provide suitable banks for bank den construction.
Watershed Re-establishment	- Minimum area of 0.8 km of stream or 1.3 km^2 of lake/marshland habitat is required. - Watercourse design should include a low gradient (5-7% slope is optimum), a meandering channel, well-defined banks (to permit the construction of stable dams) and clay soils (to ensure water retention). Water flows should be sufficient to maintain water depths of 0.9-1.5 m behind a dam. - Waterbodies should include irregular shorelines, clay substrates and water depths of 0.9-1.5 m. If the outlet is damable, beaver will modify water depths to preferred levels.
Revegetation	- A willow-aspen community is most desirable within 30 m and up to 245 m from water. Both species provide a good source of food and building materials. Willows also help stabilize watercourse banks. - Willows are best established in riparian and other hydric sites (e.g., bottom depressions) using large numbers of cuttings (dipped in root hormone). - Balsam poplar, alder, paper birch, dwarf birch are also suitable woody species for revegetation. - Water lilies are a preferred food and can be planted in reclaimed waterbodies

..... Table 18 continued.

Table 18 concluded.

Technique	Recommended Specifications
	- Conifers are not utilized and can be planted in areas where beaver activity is discouraged. - Based on feeding rates, habitat units for food (i.e., riparian shrub and aspen forest) should be a minimum of 0.6 ha.
Special Habitat Features	- Because beaver rely on woody plants for food, they may retard re-establishment of trees and shrubs. However, they are a useful key species because of their ability to regulate water levels and create water impoundments which, in turn, are beneficial to a large number of mammals and birds. - Beaver can be maintained on a site by providing food and construction materials, particularly during the late summer and fall when food caching and construction are at a peak. Freshly cut willows and aspen from adjacent natural areas will be utilized by beaver if provided close to the waterbody or watercourse.
Additional Benefits	- Reclamation of beaver habitat will provide habitat for diving and dabbling waterfowl, semi-aquatic mammals such as mink and otter and improved water supplies for terrestrial wildlife. Waterlilies may also be used by moose. Riparian shrub and tree communities will provide woody browse for ungulates and snowshoe hares.

Table 19. Reclamation objectives for muskrat in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Because of the predominantly aquatic habits of this species, topographic modification is primarily applicable to the design of waterbodies and watercourses (see below).
Watershed Establishment	- Based on home range sizes, waterbodies must provide a minimum of 200 m^2 of marshland habitat. - Overwintering water depths must exceed 0.7 m. - Watercourse habitats should have shallow gradients (3-5%), low water velocities, convoluted channels, and some well-defined clay banks (for construction of bank dens). - Waterbodies should have irregular shorelines and contain large areas (50-60% of pond) with water depths of 0.5-1.5 m to promote development of emergent aquatic vegetation. - Bottom substrates in waterbodies should be capped with a topsoil and hay mulch amendment to promote emergent growth. - Water levels in wetlands or ponds should be severely reduced during the summer period once every 5-7 years to maintain vigorous growths of aquatic plants.
Revegetation	- Two vegetation communities should be established: aquatic plants and riparian shrub. - Aquatic plants should include emergent plants such as bulrushes, cattails, reeds and some sedges, and submergent/floating plants such as duckweed or pondweed. Establish through direct transfer (of rhizomes and live plants, respectively), innoculation of the waterbody with bottom substrates from natural wetlands or direct seeding (collections of natural seed will be required). These plants provide an essential food source and construction material. Emergent plants should eventually occupy 50-60% of the pond area. - Establish riparian shrub communities along streambanks and shorelines for stabilization using numerous fresh cuttings (dipped in rooting hormone) from local willows. - Average home range sizes suggest that habitat units for food and cover should occupy at least 0.4 ha.

..... Table 19 continued.

Table 19 concluded.

Technique	Recommended Specifications
Special Habitat Features	- Not applicable
Additional Benefits	- Reclamation for muskrats will provide good habitat for dabbling waterfowl, shorebirds, marsh-associated songbirds, semi-aquatic mammals and amphibians as well as a water source for terrestrial wildlife. Riparian community development will benefit ungulates and small mammals (e.g., snowshoe hares).

Table 20. Reclamation objectives for caribou in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Prefer rolling till plains and till slopes; throughout year almost all slopes are utilized. Northwest and northeast exposures are used most in winter. Wind-swept ridges also may be an important component of winter range. - Above-grade recontouring should provide some rolling terrain through free-dumping and recontouring or through selective creation of depressions on spoil piles (e.g., along lift terraces). - Specialized shaping of spoil piles also could be used to create an undulating terrain with diverse slopes and aspects. - Below-grade recontouring could also be used to create rolling terrain.
Watershed Re-establishment	- To promote development of black spruce forest in depressional areas, drainage in the lower depressional areas of the site should be minimized.
Revegetation	- Revegetation difficult because of long time period required for habitat development (e.g. prefer climax forests) and preference for specialized foods (terrestrial and arboreal lichens) in addition to some graminoids, forbs and shrubs - Establish black spruce forest communities in depressional sites; important understory species include Labrador tea, dwarf birch, blueberry, cloud berry and willows. - Establish conifer-dominated (white spruce, black spruce and balsam fir) forests on slopes surrounding depressional sites; underplant with similar understory to black spruce forest. - Provide intermix of closed coniferous forest, open coniferous forest and open meadows by altering planting densities of seedlings. - Habitat units should be a minimum of 400 m wide in order to eventually provide protective cover; larger blocks of conifer forests are desirable to promote lichen development. - Maintenance of large islands of natural conifer cover (> 2 ha) may provide some useable immediate cover; dense clump plantings and stringers of conifers and associated understory should be used to break up the visual expanse of the site. - Development of acceptable habitat may require period of 75-100 years.

..... Table 20 continued

Table 20 concluded.

Technique	Recommended Specifications
Special Habitat Features	- Ground water seeps in excavated areas may provide salt licks. - Human disturbance after site abandonment must be minimized. - In alpine areas, snowpatches are used to avoid insect harassment and for thermoregulation; design of north-facing ridges may enhance snow-accumulation.
Additional Benefits	- Suitable habitat for this species will provide good quality habitat for some small mammals (red squirrels), some furbearers (marten and fisher), climax-associated songbirds. However, development of caribou habitat may not be possible within the normal time-frame of most developments.

Table 21. Reclamation objectives for moose in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Flat to gently-sloping terrain provides major habitats. - Rolling terrain with gentle slopes will provide diverse conditions for plant community development. - Drainage channels should be flat bottomed with broad mesic flood plains (this is compatible with beaver).
Watershed Re-establishment	- Waterbodies and watercourses are not essential features but will improve habitat and provide escape from insect harassment. - Watercourse habitats should include large riparian areas which are important for browse production and, possibly, calving. - Waterbodies should contain large shallow areas (water depth < 1 m) with amended substrates (topsoil and mulches) to promote establishment of aquatic emergents. - Develop mesic to hydric low areas adjacent to waterbodies to promote riparian tree and shrub growth.
Revegetation	- Revegetation should produce an interspersion of shrublands, deciduous forest, mixed-woods, conifer forests and muskeg forests. - Shrublands and muskeg should be developed in mesic to hydric sites, particularly in the vicinity of waterbodies and watercourses. Shrub plantings should be predominantly willows. - Deciduous and mixedwood forests should be located on better drained sites and northwest, north and east aspects. Tree plantings should include aspen, with lesser amounts of north and paper birch, white spruce and black spruce. Shrub plantings should include willow, saskatoon, red osier dogwood, choke cherry, pin cherry, and low-bush cranberry.
Special Habitat Features	- no specific requirements.
Additional Benefits	- Reclamation of moose habitat will also provide habitat for small herbivores (e.g., snowshoe hares), upland gamebirds, and songbirds. Highly compatible reclamation requirements with beaver and snowshoe hare.

Table 22. Reclamation objectives for elk in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Valley bottoms, slopes and benches appear to be the preferred terrain. - Elk are primarily associated with gently to moderately sloping terrain (<30%). Predominant use is on west, south and east exposures; western aspects most important in winter. - Slopes on west to south-facing areas should be relatively smooth in order to promote snow removal and sublimation. - Topographic features best provided by recontouring of spoil piles or specialized shaping of spoil piles.
Watershed Re-establishment	- No specific requirements
Revegetation	- Habitat should include an interspersion of grasslands and open shrublands with forested areas. - Open and sparsely treed grassland communities are the primary foraging habitat and should occupy a major portion of the site (e.g., 40-60%). Seed mixes should consist primarily of fescues, sedges, hairy wild rye and other palatable graminoids (see Table 27). - Shrub species in shrubland areas and in understories of forest communities should include willow, silverberry, buffalo-berry, saskatoon, and/or elderberry. - Forest communities should include aspen forest, aspen-white spruce mixedwoods and pine forest for foraging and cover and spruce forests for thermal cover. - Maintenance of some islands of mature conifer cover will provide immediate visual and thermal cover and will promote use of the site. - Heavy conifer cover should occupy 25% of the site in total; the remaining 75% of the site should be grassland or shrubland areas (for forage). - Forest cover habitat units (including tall shrubland) should be at least 12 ha in size. Width of open grassland or shrub habitat units should not exceed 360 m. - If site use by elk is likely to be seasonal, revegetation should focus on appropriate seasonal requirements.

..... Table 22 continued

Table 22 concluded.

Technique	Recommended Specifications
Special Habitat Features	- If suitable, exposed ground water seeps can be developed as mineral licks; if not suitable, artificial salt licks can be used. - Elk may be attracted to reclaimed sites and over-utilize ground cover and shrub foods; if elk are likely to cause plant damage problems, unpalatable species or seasonally inappropriate grasses should be included in the seed mix. Mineral licks also should not be developed.
Additional Benefits	- Representative of wildlife associated with grassland-shrubland transitions and some forest communities. Because elk quickly accept reclaimed areas when human disturbance is minimized, the presence of animals on the site provides a positive psychological benefit to reclamation operators/workers and the public.

Table 23. Reclamation objectives for mountain goat in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Broken, steep (>45%), predominantly west to south facing slopes and cliffs with adjacent moderate slopes (<30%) provide year-round habitat; wind-swept west to south facing slopes with steep broken terrain provide best winter range. - Mine highwalls offer potentially good habitat, particularly if pre-planning and the location of the ore body or coal seam permit orientation as described above. - Ledges and narrow pathways along the cliff or slope face should be created, if not already present, to provide a network of escape trails. - Overhangs or shallow caves in association with the highwall or in proximity (<200 m) to escape terrain provide summer bedding areas.
Watershed Re-establishment	- No specific requirements
Revegetation	- Mosaics of grass/forb meadows and low shrubland provide good foraging habitat; these areas should extend 200 - 400 m from all sides of suitable escape terrain (highwalls). - No forest cover should be established within 200 - 400 m of the escape terrain to minimize protective cover for predators. - Grassland area should include fescues, wheatgrasses, bromes, sedges, wild rye and june grass. - Shrub meadow areas should include plantings of at least several of: silverberry, buffaloberry, saskatoon, alder, rose, and willow.
Special Habitat Features	- Highwall development as discussed above.
Additional Benefits	- Mountain goats provide a good key species for development of highwalls or steep rocky slopes. Cliff features will also benefit some raptors (nesting and perch sites) and small mammals (e.g., pikas and ground squirrels in potential talus sites).

Table 24. Reclamation objectives for bighorn sheep in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Steep broken terrain and talus slopes are important habitat features for bedding, escape terrain, and lambing. - Almost all aspects are used throughout the year but south and west facing slopes are usually most important as winter range. - Some highwalls may provide suitable habitat for bighorn sheep; steep-sided spoil piles or dumps may also be appropriate. - Shallow caves and overhangs are used for cover during major storms. - Flat meadow areas should be developed adjacent to and no further than 0.8 km from steep slopes or highwalls (e.g., escape terrain). - If the highwall toe is relatively free of rock debris, moderate to large sized rock (preferably granitic or other metamorphic rock) should be dumped at the toe to provide a talus slope.
Watershed Re-establishment	- No specific requirements.
Revegetation	- Grasslands and grass/forb meadows are the major foraging habitats. Forested edges are also used for foraging and thermal cover. - Fescues, wheatgrasses, june grass and sedges should predominate seed mixes for the grassland community. Seed mixes for grass - forb meadows should include composites and legumes as well as the graminoids listed above. - Adjacent forested communities should provide some dense conifer cover for thermal protection.
Special Habitat Features	- Highwall development as discussed above.
Additional Benefits	- Development of mountain sheep habitat will provide habitat for some specialized small mammals such as pika, ground squirrels and marmots as well as raptors, some gamebirds and songbirds. Talus areas may also eventually provide specialized habitats for caribou (calving). Meadow habitats will benefit elk, grizzly bear and black bear.

Table 25. Reclamation objectives for spruce grouse in the Mountain and Foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Prefer flat to gentle slopes (<7%) and valley bottoms.
Watershed Re-establishment	- No specific requirements
Revegetation	- Prefer lodgepole forests but will also use white spruce and other conifer-dominated forests. Optimal stage of forest development for use occurs when tree branches are still close to ground (e.g., 5-10 m). - Tree plantings should provide mature canopy with an average canopy closure of 50% and 5000-6000 stems/ha. Lodgepole pine provides good cover and is a preferred food. Scattered white spruce also provide good nesting habitat and are a preferred food of incubating females. - Shrub understory in most areas should be <25% but several dense copses should be provided in each habitat unit for moulting and nesting cover. Shrub species should include some willows, blueberry, juniper, and alder. - Some small open areas (< 0.1 ha) are required for male display flights. - Uniform, aggregated territories range up to 3.9 ha but can be much larger in dispersed population areas. This suggests that habitat units should be 3.0 - 4 ha.
Special Habitat Features	- No specific requirements
Additional Benefits	- Although the habitat requirements of spruce grouse are moderately specific, development of suitable habitat for this species will ensure habitat diversity in conifer-associated habitats. This will benefit a number of species such as red squirrel, snowshoe hares and some ungulates that rely partially or are dependent on conifer communities for cover and/or food.

Table 26. Reclamation objectives for white-tailed ptarmigan in the Mountain and foothill biomes.

Technique	Recommended Specifications
Topographic Modification	- Open rocky slopes and alpine cirques provide summer and some winter habitat. Valley bottoms 2.5-7.5 km downslope of summer habitat may be used during deep snow years. - In rocky areas, rocks larger than 30 cm diameter should be provided for hiding and thermal cover. - Rough terrain will provide good winter habitat; windswept ridges are used for feeding while snow accumulations in depressions provide thermal cover. - Free-dumping or specialized contouring of rock rubble could be used to create irregular terrain.
Watershed Re-establishment	- During summer, habitat units should occur close to snowfields or rocky alpine streams (usually within 25 m); damp soils in these sites provide suitable growing conditions for some of the preferred foods. - Stream courses may also be important during winter because of the vegetation association.
Revegetation	- Moist rocky alpine tundra provides the most suitable summer habitats; potential plant species include willows, sedges, heaths, fleabanes, dryas and buttercups. - Shrubland and open conifer forests are important winter habitats. - Shrubland areas should include one to several species of shrubs including: willow, dwarf birch and juniper. Willow copses 2-3 m in height provide important thermal cover and food during severe winters. - Forest cover should include alpine fir, Engelmann spruce, whitebark pine, and/or alpine larch. Shrub understories should also be included in these plantings. - Optimal spacing and sizes for habitat units are unknown.
Special Habitat Features	- Supplemental winter feeding with grain may allow animals to become established earlier on the reclamation site.
Additional Benefits	- White-tailed ptarmigan is the only key species for high subalpine to alpine conditions. Creation of habitat for this species will eventually provide seasonal habitat for other wildlife such as caribou, elk, grizzly and black bears, small mammals (ground squirrels, marmots and pikas), and songbirds.

Table 27. Species of plants with known suitability for reclamation and used by wildlife for food or cover in the Mountain and Foothill biomes (Sources: Watson et al. 1980; P.F.R.A. n.d.; J. Stelfox, pers. comm.).

	Wildlife	Ungulates	Bighorn Sheep	Deer	Mule Deer	White tailed Deer	Elk	Moose	Bears	Beavers	Rabbits, Hares	Red Squirrels	Chipmunks, Pikas	Birds	Game Birds	Waterfowl	Comments
Bluegrass, Canada																	palatable to livestock
Bluegrass, Kentucky			F		F		F	F									palatable to livestock
Bluejoint																	moderately palatable to livestock
Barley, Foxtail					F										F.C		unpalatable seeds, but palatable before flowering
Brome, Awnless		F															palatable to livestock
Canary Grass, Reed					F.C										F.C		low palatability to livestock
Fescue			F		F		F	F									
Fescue, Red																	highly palatable to livestock
Fescue, Sheep					F										F.C		low to moderate palatability to livestock
Foxtail, Creeping				F			F										moderately to highly palatable to livestock
Hair Grass, Tufted					F				F						F		palatable to livestock
June Grass			F		F		F	F									highly palatable to livestock
Needle Grass					F										F		palatable to livestock before going to seed
Orchard Grass	F																highly palatable to livestock
Redtop	F.C																low palatability to livestock
Rice Grass, Indian				F	F									F	F		palatable to livestock
Ryegrass																	palatable to livestock
Sand Grass					F										F		palatable to livestock
Sedge			F		F		F	F									
Timothy		F												F			palatable to livestock
Wheat Grass, Crested																	moderately to highly palatable to livestock
Wheat Grass, Intermediate																	palatable to livestock
Wheat Grass, Pubescent			F				F	F									palatable to livestock
Wheat Grass, Slender			F				F	F									moderately palatable to livestock
Wheat Grass, Streambank																	low palatability to livestock
Wheat Grass, Tall																	moderately palatable to livestock
Wild Rye, Hairy																	not palatable where palatable species are available
Wild Rye, Russian				F													highly palatable to livestock
FORBS																	
Clover, Alsike					F										F		palatable to livestock
Clover, Red					F										F.C		highly palatable to livestock
Clover, White					F										F		highly palatable
Hedysarum		F	F				F		F								palatable to livestock, H. mackenzie poisonous
Loco weed, Late Yellow																	poisonous to livestock
Medick					F												palatable to livestock
Milk Vetch, Cicer			F		F		F	F									palatable to livestock
Pea Vine	F																
Sainfoin	F																palatable to livestock
Sweet Clover					F										F.C		palatable to livestock
Trefoil, Birdsfoot																	highly palatable to livestock
Vetch, Wild	F				F										F		highly palatable to livestock
Willow herb					F			F					F				
TREES AND SHRUBS																	
Alder, Green					F			F									
Alder, River					F		F										
Bearberry, Common					F				F					F	F		
Birch, Paper								F									moderately palatable
Buckbrush					F												
Buffalo berry, Canadian				F			F		F								low palatability
Buffalo berry, Thorny														F.C	F.C		low palatability
Cherry, Choke		F		F	F	F	F							F	F		
Cinquefoil, Shrubby			F		F		F										low palatability
Crabapple, Siberian					F	F					F	F		F.C	F		
Dogwood	C			F	F.C		F	F			F			F	F		
Elderberry												F		F	F		low palatability
Fir, Alpine				F			F	F			F						
Hawthorn				F							F			F	F		
Juniper, Creeping					F												
Juniper, Ground	not eaten													F			
Maple, Manitoba	avoided																low palatability
Oak, Bur					F	F							F	F	F	F	
Pear, Ussurian	C																low palatability
Pine, Lodgepole					F						F						
Poplar, Aspen			F	F	F		F	F									palatable to livestock
Poplar, Balsam		F								F							
Raspberry, Wild Red	F																
Rose, Common Wild		F			F.C		F								F.C		highly palatable
Rose, Hedge					F	F								C	F		
Rose, Prickly					F									F	F		
Russian Olive														F	F.C		
Saskatoon					F.C	F	F	F			F			F.C	F		moderately to highly palatable
Sea Buckthorn				F											F		
Silverberry			F		F												low palatability
Snowberry				F	F		F							F			
Spruce, White					C		C				F	F					
Willow			F		F		F	F									
Willow, Bebb				F				F			F						
Willow, Grayleaf								F									
Willow, Scouler					F.C			F							F.C		

F = FOOD C = COVER

10.0 POTENTIAL WILDLIFE PROBLEMS IN RECLAMATION[1]

10.1 ATTRACTION OF WILDLIFE TO RECLAMATION AREAS

Reclamation of wildlife habitat may generally be considered a problem of creating habitat that is attractive to wildlife. Once wildlife are present, however, they may hamper the reclamation effort through overuse of tree and shrub browse (e.g., deer and hare damage to seedlings), trampling of seedlings, and girdling of seedlings (e.g., small mammal damage). Below, we briefly describe the most common types of wildlife problems that have occurred at reclamation areas in Alberta and suggest potential control measures.

10.1.1 Browsing Damage to Trees and Shrubs

Ungulate damage to trees and shrubs has been reported by a number of mines in the Hinton-Edson region and in the southeast-coal block of British Columbia-Alberta. Several kinds of damage have been observed including overbrowsing, debarking and uprooting. Frequent browsing of established seedlings and clipping of newly-planted seedlings may result in decreased seedling vigor and mortality (von Althen 1983). Clipping of conifer leaders by ungulates and snowshoe hares has been reported at the Coal Valley (C. Brinker, pers. comm.), Cardinal River Coal (G. Acott, pers. comm.), MacIntyre (V. Betts, pers. comm.) and Westar mines (T. Milligan, pers. comm.). At the Westar mine, overbrowsing of planted seedlings and adjacent native shrub communities by elk resulted in the mortality of some plants (Courtney 1977; T. Milligan, pers. comm.). Uprooting of newly-planted seedlings and bark stripping of aspens was also reported (Courtney 1977; T. Milligan, pers. comm.; P. Ziemkiewicz, pers. comm.).

10.1.2 Trampling Damage to Trees and Shrubs

Trampling damage has only been reported on the Cardinal River mine site (G. Acott, pers. comm.). Bighorn sheep frequently bedded on the shrub and tree seedlings within the island plantings and contributed to the mortality of the seedlings through direct crushing and increased exposure to wind and snow abrasion (by removal of the protective snow cover). Bighorn sheep in Banff National Park also were observed to reduce the effectiveness of soil stabilizing mulches by trampling (Harrison 1984).

10.1.3 Girdling Damage by Small Mammals

Girdling damage by small mammals appears to be a common problem in reclamation sites where trees and shrubs have been planted in areas of established grass and legume cover (Green 1980; Scheidemann and Stelfox 1981). Girdling damage by microtine rodents and snowshoe hares can substantially reduce the success of reforestation programs by direct mortality of seedlings and young trees, weakening the seedling and increasing its susceptibility to insects and disease, and reduction of seedling growth (Jokela and Lorenz 1959; Cayford and Haig 1961; Buckner 1970; Radvanyi 1978; von Althen 1983). Substantial amounts of girdling by small mammals (mostly microtine rodents) has been reported at the Judy Creek test site (Esso Resources 1984) and at the Cardinal River (G. Acott, pers. comm.), Coal Valley (C. Brinker, pers. comm.) and Westar (T. Milligan, pers. comm.) mines. A review of small mammal (mice, squirrels and snowshoe hare) damage to trees and shrubs (Green 1979) indicates that damage to woody plants by small mammals has been an important limiting factor to the establishment of trees and shrubs in areas that have first been revegetated with dense grass and legume ground covers.

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[1] Parts of this section have been extracted with modifications from Green et al (1985a).

10.2 CONTROL OF WILDLIFE PROBLEMS

Several reviews have summarized methods of controlling wildlife damage in reclamation areas. The USDA (1979) assessed livestock and wildlife problems in reclamation areas as well as direct and indirect methods of controlling these problems. Green (1978) reviewed information on chemical, mechanical and environmental controls of small mammal damage to plants. Von Althen (1983) discussed a variety of mammal problems in reforestation areas in eastern Canada and recommended methods of control. A recent review by Sims et al. (1984) provides an overview of large and small mammal use of reclamation areas and methods of control.

10.2.1 Control of Large Mammal Problems

10.2.1.1 Indirect Control. Indirect control measures for large mammals such as elk, moose and deer can involve altering physical features of the site as well as increasing public access to the site to reduce its attractiveness to wildlife.

10.2.1.1.1 Plant Selection. Plant species that are not consumed by the problem species can be utilized on the reclamation site. This could involve the use of unpalatable species (see species accounts for habitat requirements; Volume II) or the use of physically less edible (e.g., thorny) species such as Russian Olive, ground juniper or caragana. Observations of reduced browse damage on some tree species (e.g., spruce) when planted in mixed-planting (e.g., spruce with pine) (C. Brinker, pers. comm.) suggest that mixed plantings of preferred and unpreferred species may offer a partial solution to browse damage. However, no information is currently available on the optimal mixtures or dispersion of plants for control or the effectiveness of mixed plantings for control. Planting of high densities of shrubs or trees (i.e., saturation planting), such as the use of large numbers of fresh shrub cuttings, can also ensure that some plants will survive (C. Fooks, pers. ob.).

10.2.1.1.2 Hunting. Use of reclamation sites by problem animals may be controlled through use of controlled hunts (e.g., by government personnel) or recreational hunting. Public bow hunting of bighorn sheep on the Cardinal River mine site (G. Acott, pers. comm.) was initiated during fall 1984 to reduce bighorn sheep grazing on the reclamation site. Initial results indicated that the sheep responded quickly to the hunting pressure (i.e., moved off the mine site) but that they returned rapidly once hunting ceased. Public hunting of elk at the Westar site is proposed for the 1985 season (T. Milligan, pers. comm.). The effectiveness of public hunting programs in reducing wildlife use of reclaimed sites may be increased by use of scaring devices (e.g., propane canons) and intermittent reinforcement (e.g., selective killing of 1-2 animals).

10.2.1.1.3 Hay Mulches. Although hay mulches are not widely used on many reclamation sites, hay and straw mulches may attract some ungulates such as elk and deer and, whenever possible, should not be used. Mulches also provide excellent cover for microtines and may result in high levels of girdling damage to trees and shrubs (Green 1978).

10.2.1.1.4 Attractants. Attractants have been suggested as a means of luring animals from the reclaimed sites. The effectiveness of attractants such as sweeteners, trace elements or salts sprayed on adjacent plant communities in reducing browse damage has not been widely tested (e.g., Dasmann et al. 1967). Habitat enhancement in natural areas adjacent to a development site has been used to reduce disturbance effects on wildlife by attracting wildlife away from the major development areas (G. Mann, pers. comm.) and has been recommended for mitigating effects of linear ROWs on ungulates (Kemp 1985). The usefulness of habitat enhancement to reduce damage to trees and shrubs in unknown.

Intercept feeding programs have been used in Saskatchewan and Manitoba to reduce deer and elk damage to crops and haystacks (Goulden 1985). Feeding stations stacked with alfalfa hay or pellets are usually located away from the problem site and are used in conjunction with applications of blood meal repellents around the damaged crop. No examples of use of this technique for control of mammal damage to woody plants are known.

10.2.1.1.5 Availability of Permanent Water. Permanent water may attract some mammals such as elk to an area or may encourage migratory species to remain in an area. As a result, waterbodies on a reclamation site should be located away from susceptible tree planting areas.

10.2.1.2 Direct Control.

10.2.1.2.1 Use of Protective Fencing. Reclaimed areas susceptible to overuse by wildlife can be enclosed with fencing. The most effective designs include 2.5 - 3.0 m high wire fencing or electric fencing (e.g., Kinsey 1976; Caslick 1980). Electric fencing may be of limited use in some areas since it becomes ineffective during deep snows (Kinsey 1976). Because of the high construction and maintenance costs of fences, fencing is only practical for protecting high concentration plantings of trees and shrubs (e.g., topsoil islands) as opposed to entire reclamation sites.

10.2.1.2.2 Protective Mesh or Tubing. Protection of seedlings or conifer leaders with plastic tubes or mesh (USDA 1979) is impractical for most large reclamation areas but may be useful in small scale plantings (e.g., shrub or tree clumps).

10.2.1.2.3 Repellents. Trees and shrubs may be protected by application of repellents. Two types of repellents -- odor repellents and taste repellents -- may be of some use (von Althen 1983). Odor repellents include substances such as tankage (e.g., blood meal), moth balls and resin. Taste repellents are generally more effective than odor repellents (von Althen 1983) and commonly contain either zinc dimethyldithiocarbamate cyclohexamine complexes (ZAC) or tetramethyl thiuran disulphide (TMTD). Repellents can be applied efficiently to large numbers of seedlings but must be reapplied 1-2 times annually. In areas where seedlings are fertilized or irrigated, the resulting lush growth may attract animals and be utilized despite the presence of the repellent.

10.2.2 Control of Small Mammal Problems

Methods of controlling small mammal damage to plants in reclamation areas were reviewed by Green (1978) and the reader is referred to this review for specific details. Three types of methods have been commonly utilized to control small mammal problems: chemical, mechanical or environmental controls. Chemical controls include repellents, chemosterilants, multiple dose rodenticides (e.g., anticoagulant-based poisons), and single-dose rodenticides (e.g., strychnine). Mechanical controls can involve physical barriers such as metal or plastic shields and fences, sonic repellents, and traps. Environmental controls encompass habitat manipulation, biological control, genetic manipulation and attractants (e.g., lure baits). Based on the advantages and disadvantages of each control method and the feasibility of the method for large scale control programs, Green (1978) concluded that control methods which directly reduce small mammal numbers are the least effective for controlling damage. Methods that directly remove animals such as chemosterilants, rodenticides, trapping and biological control interfere with natural regulatory processes in the pest population, and in some cases, may result in a compensatory increase in animal densities. Several of these controls also pose serious hazards to non-target species. In contrast, methods that focus on reduction of damage such as habitat manipulation, attractants, repellents and mechanical barriers are effective and are preferred; natural regulatory processes are less likely to be disrupted and direct or secondary poisoning hazards are low or nonexistent.

Small mammal problems in reclamation areas are most effectively controlled through multi-treatment programs that involve habitat manipulation, attractant foods and, possibly, repellents. For example, by substantially decreasing the abundance of graminoids and legumes and the total density of the ground cover canopy, the suitability of the area for microtine rodents (the group of rodents suspected of causing most girdling damage) is greatly reduced. Consequently, fewer animals are present without disruption of natural regulatory processes, and girdling damage to trees and shrubs is reduced. Application of repellents on trees and shrubs and provision of alternative foods (e.g., lure baits) may help to reduce further amounts of damage (Green 1978).

10.3 HUMAN - WILDLIFE INTERACTIONS

As a safety precaution, hunting is prohibited within most mine sites during the pre-mining, operational and early abandonment phases of a mine. Assuming that portions of the mine site are useable by wildlife, the development site often provides a sanctuary from hunting for wildlife. Because mine sites may remain active for one to several decades, animals that utilize undisturbed and reclaimed lands may become accustomed to the lack of hunting and new cohorts may not be exposed to hunting. If areas are specifically reclaimed for wildlife, mine sites will be even more attractive to wildlife. Current land use legislation does not permit the restriction of public access to Crown land, hence the areas will be open to hunting on reversion to the Crown, unless special dispensation is granted by a government agency. A number of studies have shown that large mammals in previously unhunted areas are highly vulnerable to hunting and are easily overharvested once an area becomes accessible (e.g., Bergerud et al. 1968; McIlroy 1972; Lynch 1973; Leege 1976). It is reasonable, therefore, to assume that wildlife in protected reclamation areas may also be more susceptible to hunting, once a reclamation area is abandoned and made accessible to the public. No documentation on this potential effect exists since none of the protected reclamation areas in this province have yet been abandoned.

The potential for overharvesting may be reduced by restriction of public access on abandonment or by conditioning the animals prior to abandonment. Once an area reverts to the Crown, public access could be gradually re-introduced to allow wildlife to adapt. Wildlife could also be conditioned prior to abandonment through use of organized or controlled hunts. For example, Cardinal River Coal and Westar Mining have conducted or planned controlled public hunts of bighorn sheep and elk, respectively, on their properties, primarily to control overuse of the sites by wildlife (G. Acott, pers. comm.; T. Milligan, pers. comm.). Organized hunts by government or mine personnel could be implemented several years prior to full abandonment of a site to re-introduce gradually the wildlife to hunting pressure.

11.0 PROPOSED DECISION MAKING PROCESS FOR WILDLIFE HABITAT RECLAMATION

In order to plan effectively and implement a reclamation program for wildlife habitat enhancement, a process for identifying, describing and undertaking such a program should be established. We have proposed a decision making process intended to address these needs. The importance of beginning such a process at the earliest point in time of a project cannot be overemphasized. Even so, such a process can be implemented at any point in the existence of a project and still result in beneficial wildlife habitat enhancement.

The proposed decision making process has four major steps and each step with an accompanying flow diagram is discussed below.

11.1 STEP ONE: IDENTIFICATION OF RECLAMATION REQUIREMENTS

In the proposal for all projects, there is an opportunity to define clearly the nature and level of concern for project effects on wildlife and wildlife habitat. Additionally, it is possible to establish which elements of project activity have the greatest effect on wildlife and wildlife habitat and within the scope of project operations, amend them appropriately. From this, an accurate estimate of the scope of disturbance may be established and the requirements for reclamation of wildlife habitat identified. Figure 11 indicates a proposed decision process for reaching this stage.

11.2 STEP TWO: DEVELOP A CONCEPTUAL RECLAMATION PLAN AND SCHEDULE

With the identification of the requirements for wildlife habitat reclamation, it is necessary to integrate the overall reclamation plan with other end uses for the development. From this integration of end uses, the identification of target species is required to determine specific habitat types and their locations on the site so that a detailed reclamation plan and schedule may be developed. With the detailed plan in place, the critical phase of selecting reclamation techniques for the target species can be implemented. Figure 12 indicates a proposed decision process for reaching the stage where the conceptual plan and schedule is developed.

11.3 STEP THREE: IMPLEMENT RECLAMATION PLAN

With the conceptual plan in place, the identification of reclamation techniques for the target species begins and is integrated with the site operations plan particularly in the areas of recontouring, watershed re-establishment and the maintenance of natural features. Reclamation techniques should be initiated at the earliest practical time in site operations so that habitat enhancement benefits may be realized as soon as possible. Additionally, the early implementation of elements of the total reclamation program allows testing of various procedures and techniques to ensure maximum return on effort for the total program. The decision process for reaching the stage of implementing the reclamation plan is shown in Figure 13.

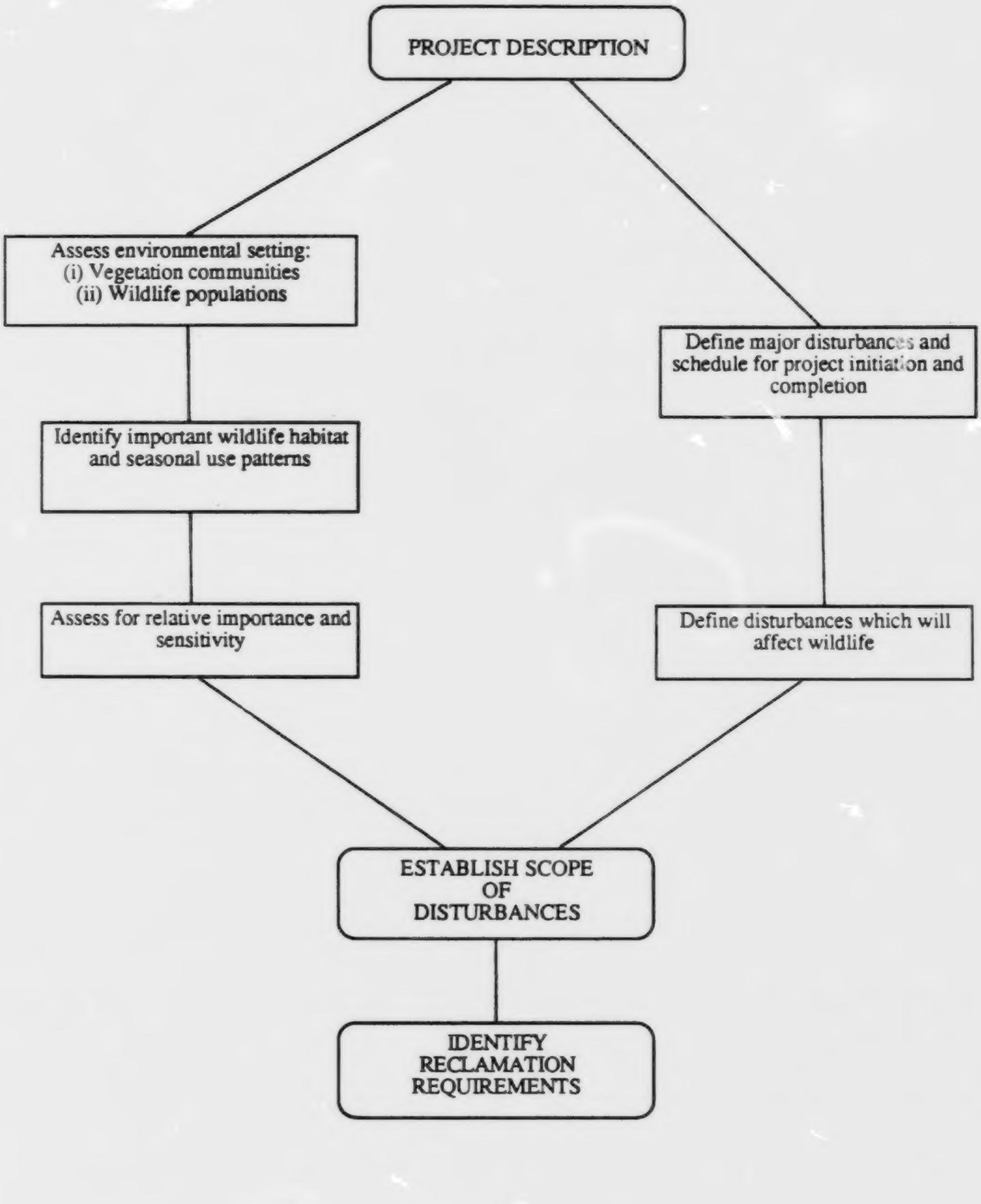
PROJECT DESCRIPTION
Assess environmental setting:
(i) Vegetation communities
(ii) Wildlife populations
Define major disturbances and schedule for project initiation and completion
Identify important wildlife habitat and seasonal use patterns
Assess for relative importance and sensitivity
Define disturbances which will affect wildlife
ESTABLISH SCOPE OF DISTURBANCES
IDENTIFY RECLAMATION REQUIREMENTS

Figure 11. Identification of reclamation requirements.

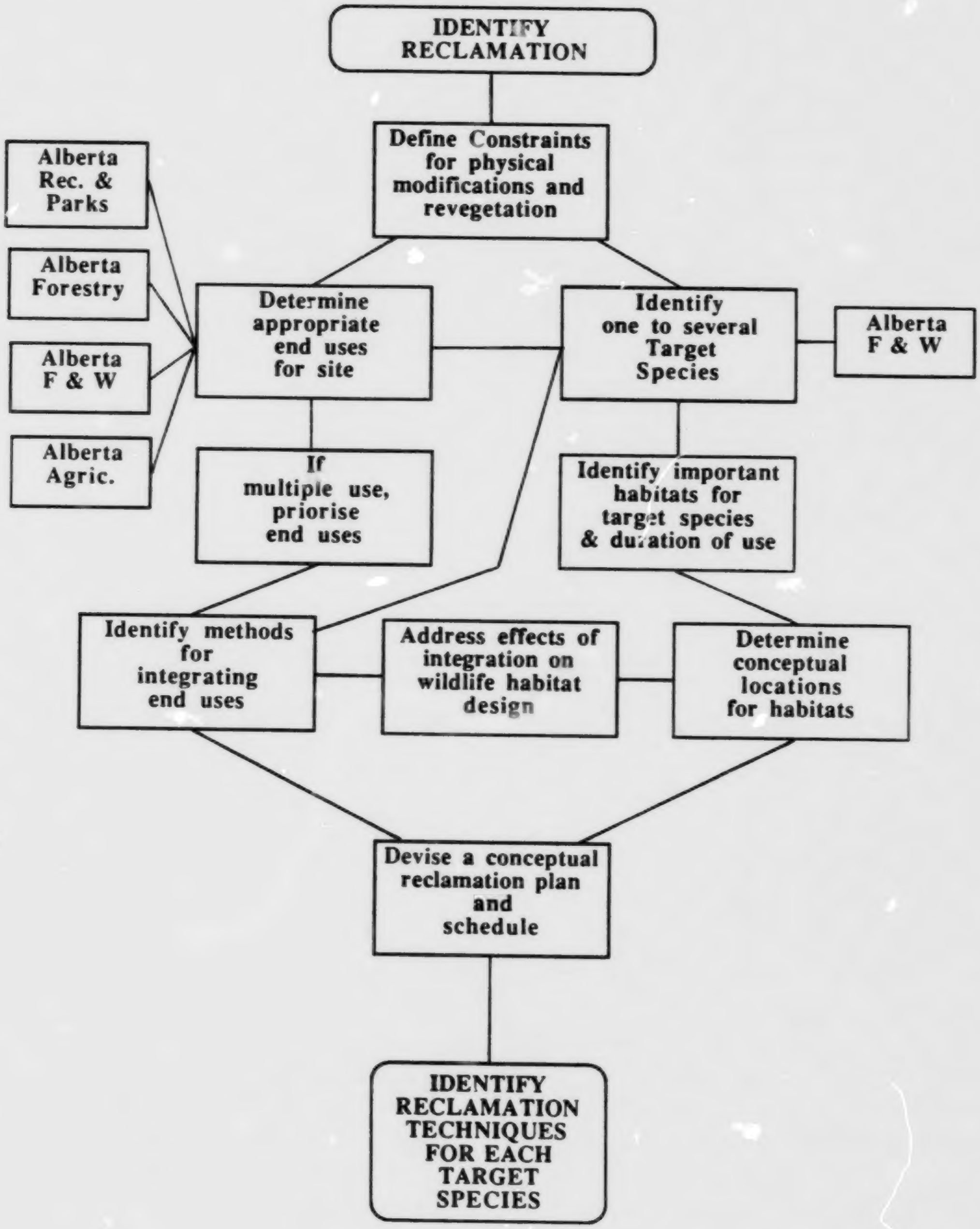
IDENTIFY RECLAMATION
Define Constraints for physical modifications and revegetation
Alberta Rec. & Parks
Alberta Forestry
Alberta F & W
Alberta Agric.
Determine appropriate end uses for site
Identify one to several Target Species
Alberta F & W
If multiple use, priorise end uses
Identify important habitats for target species & duration of use
Identify methods for integrating end uses
Address effects of integration on wildlife habitat design
Determine conceptual locations for habitats
Devise a conceptual reclamation plan and schedule
IDENTIFY RECLAMATION TECHNIQUES FOR EACH TARGET SPECIES

Figure 12. Development of the conceptual reclamation plan and schedule.

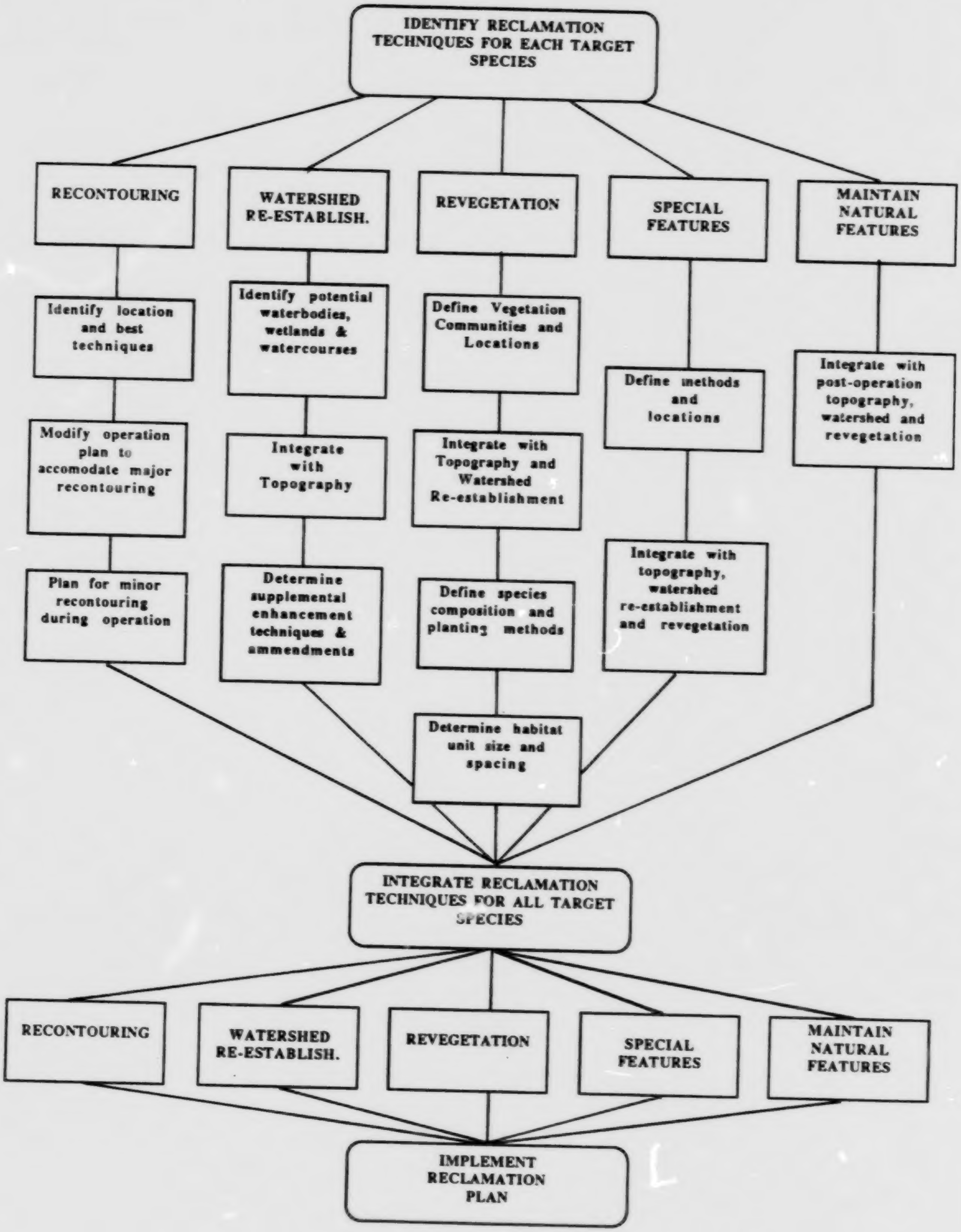
IDENTIFY RECLAMATION TECHNIQUES FOR EACH TARGET SPECIES
RECONTOURING
WATERSHED RE-ESTABLISH.
REVEGETATION
SPECIAL FEATURES
MAINTAIN NATURAL FEATURES
Identify location and best techniques
Modify operation plan to accomodate major recontouring
Plan for minor recontouring during operation
Identify potential waterbodies, wetlands & watercourses
Integrate with Topography
Determine supplemental enhancement techniques & ammendments
Define Vegetation Communities and Locations
Integrate with Topography and Watershed Re-establishment
Define species composition and planting methods
Determine habitat unit size and spacing
Define methods and locations
Integrate with topography, watershed re-establishment and revegetation
Integrate with post-operation topography, watershed and revegetation
INTEGRATE RECLAMATION TECHNIQUES FOR ALL TARGET SPECIES
RECONTOURING
WATERSHED RE-ESTABLISH.
REVEGETATION
SPECIAL FEATURES
MAINTAIN NATURAL FEATURES
IMPLEMENT RECLAMATION PLAN

Figure 13. Implementation of the reclamation plan.

11.4 STEP FOUR: MONITORING AND CERTIFICATION

In terms of the operational life of a project, the reclamation plan should begin almost simultaneously with site operations. At all phases, it is necessary to assess the benefits of wildlife habitat reclamation in order to modify or revise the program to maximize benefits. Upon cessation of site operations and completion of final reclamation, the results of the reclamation work should be assessed using the target species models. If the results are acceptable the proponent should receive the reclamation certificate and the site should be abandoned. The decision process for this stage is presented in Figure 14.

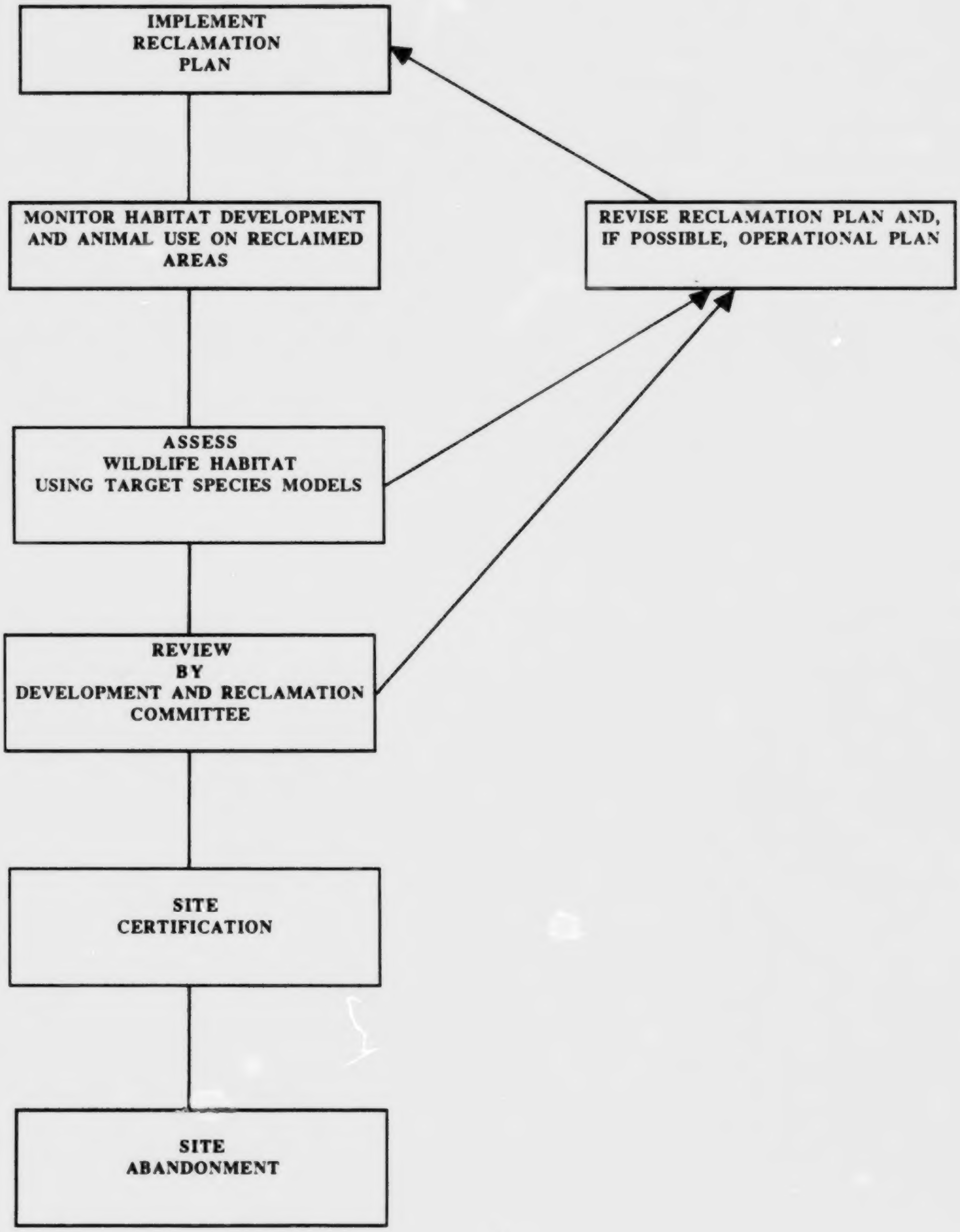
IMPLEMENT RECLAMATION PLAN
MONITOR HABITAT DEVELOPMENT AND ANIMAL USE ON RECLAIMED AREAS
ASSESS WILDLIFE HABITAT USING TARGET SPECIES MODELS
REVIEW BY DEVELOPMENT AND RECLAMATION COMMITTEE
SITE CERTIFICATION
SITE ABANDONMENT
REVISE RECLAMATION PLAN AND, IF POSSIBLE, OPERATIONAL PLAN

Figure 14. The monitoring and certification process.

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13.0 APPENDICES

13.1 APPENDIX 1: INDIVIDUALS INTERVIEWED FOR THIS STUDY AND BY GREEN ET AL. (1985)

Names, affiliations and date of contact of individuals interviewed during this study (April - October 1985) and by Green et al. (1985) (December - February 1985) for the Mountain and Foothills Reclamation Research Program.

Date	Name	Affiliation
18 December	Linda Foubuster	B.C. Fish and Wildlife
20 December	John Dick	B.C. Ministry of Environment
3 January	Roger Burton	Peter Kewit Incorporated, Wo.
3 January	John Kirkland	Saskatchewan Dep. of Mines
3 January	Peter Marten	Montana Dep. Fish and Wildlife
3 January	Sheldon McLeod	Saskatchewan Dep. of Environment
3 January	John Monday	Montana Dep. Fish and Wildlife
3 January	William Schoekoph	Western Energy, MT.
3 January	Bruce Waege	Western Energy, MT.
7 Janaury	Lowell Adams	Institute of Urban Ecology, Washington, D.C.
7 January	Robert Comer	Thorne Ecological Inst., CO.
7 January	Larry Jones	Idaho Dep. of Game and Fish
7 Janaury	Karen McGordon	Idaho Bureau of Reclamation
7 January	Darrel Svedersky	Univ. of Minnesota
8 January	Gary Amestoy	Administration of Reclamation, MT.
8 January	Gomer Jones	Nat'l. Inst. of Urban Wildlife, MY.
8 January	Michele Mitchell	Westmoreland Mines, MT.
8 January	Marlin Murphy	Gregg River Coal, Alta.
15 January	Jeff Bondy	Alberta Forest Service
15 January	Rick Ferster	Luscar Mines, Alberta
15 January	Burton Poston	Canadian Wildlife Service, Alta.
16 January	Paul Ziemkiewicz	Reclamation Research Technical Advisory Committee
16 January	William Wishart	Alberta Fish and Wildlife Division
17 January	Alan J. Kennedy	Esso Resources Canada Limited, Alta.
21 January	Karen Natsukoshi	ManAlta Coal Ltd., Alta.
28 January	Lin Callow	Gulf Canada Resources Limited, Alta.
29 January	Tim Adamson	Union Oil, Alta.
29 January	Bill Davidson	Idaho Fish and Game Department
29 January	Phil Lulman	TransAlta Utilities, Alta.
29 January	Tony Milligan	Westar Mining, B.C.
29 January	Gerry Thiessen	Idaho Fish and Game Department
30 January	Vern Betts	MacIntyre Mines, B.C.
30 January	Curtiss Brinker	Luscar-Sterco, (Coal Valley Mine), Alta.
30 January	Roger Burdussco	Fording Coal, B.C.
30 January	Terry Masyck	Alberta Research Council, Alberta
31 January	Gerry Acott	Cardinal River Coal, Alta.
31 January	Dermot Lane	Fording Coal, B.C.

Date	Name	Affiliation
31 January	Jim Lant	Crowsnest Resources, B.C.
31 January	John Wisch	Widco, Washington State
1 February	Brent Densmore	Crowsnest Resources, B.C.
2 April	Bob Logan	Luscar-Sterco (Diplomat Mine), Alta.
23 May	Malcolm Ross	Crownest Resources, Alta.
15 July	Carl Surrendi	Carsal Enterprises, Alberta
16 July	Brian Curran	Saskatchewan Power Corporation
16 July	Joseph Dean	Saskatchewan Parks and Renewable Resources, Fisheries Branch
16 July	Garry Douglass	Saskatchewan Power Corporation
16 July	Ross Melinchuk	Saskatchewan Parks and Renewable Resources, Wildlife Branch
16 July	Joseph Muldoon	Saskatchewan Parks and Renewable Resources, Fisheries Branch
16 July	Wayne Nordquist	Saskatchewan Power Corporation
17 July	Ron St. Ange	Saskatchewan Power Corporation
24 July	M. Mulligan	Smokey River Coal, Alberta
2 October	Terry Antoniuk	Gulf Canada Ltd., Alta.
2 October	Don Thompson	Syncrude Canada Ltd., Alta
4 October	Gail Harrison	Parks Canada, Western Region, Calgary
7 October	George Granger	Alberta Agriculture (Ross Nursery)
7 October	Karen Natsukoski	ManAlta Coal, Alta.
8 October	Klaus Exner	NOVA, An Alberta Corporation, Alta.
8 October	Ron Findlay	Amoco Canada, Alta.
8 October	Don Klym	Suncor Inc., Alta.
8 October	Gordon Lambert	Esso Resources Canada Ltd., Alta.
8 October	Michael Robertson	Petro-Canada, Alta.
10 October	Ludwig Carbyn	Canadian Wildlife Service, Alta.
10 October	John Stelfox	Canadian Wildlife Service, Alta.
10 October	Garry Trottier	Canadian Wildlife Service, Alta.
11 October	Mark Leskey	Husky Oil Limited, Alta.
15 October	Dennis Kohlman	Petro-Canada, Alta.
17 October	Michael Enwright	Canterra Energy Limited, Alta.
17 October	Garry Mann	Esso Resources Canada Ltd., Alta.
17 October	David McCoy	Canterra Energy Limited, Alta.
17 October	Tim Shopik	Suncor Inc., Alta.
17 October	Steph Stephenson	Canstar Energy Limited, Alta.
18 October	Dean Mutrie	Mutrie-Wishart Limited, Alta.
18 October	Gary Stewart	Ducks Unlimited Canada, Alta.
21 October	Donald Dabbs	Dabbs Environmental Services, Alta.

13.2 APPENDIX 2: LIST OF COMMON AND SCIENTIFIC NAMES USED IN TEXT

13.2.1 List of Common and Scientific Names of Plant Species

	Common Names	Scientific Names
Forbs		
	Bulrush	Scirpus spp.
	Buttercup	Ranunculus spp.
	Cattail, (Common)	Typha latifolia
	Clover, Alsike	Trifolium hybridum
	Clover, Red	Trifolium pratense
	Clover, White	Trifolium repens
	Duckweed	Lemna spp.
	Fireweed	Epilobium spp.
	Fleabane	Erigeron spp.
	Hedysarum	Hedysarum spp.
	Loco-weed, Late Yellow	Oxytropis campestris
	Lupine, Perennial	Lupinus argenteus
	Alfalfa	Medicago spp.
	Milk Vetch, Cicer	Astragalus cicer
	Pea Vine	Lathyrus ochroleucus
	Pondweed	Potamogeton spp.
	Reed	Phragmites communis
	Sainfoin	Onobrychis viciifolia
	Sedge	Carex spp.
	Sedge, Ross's	Carex rossii
	Sweet Clover	Melilotus spp.
	Trefoil, Birdsfoot	Lotus corniculatus
	Vetch, Wild	Vicia americana
	Water-lily	Nymphaea spp.
Trees and Shrubs		
	Alder	Alnus spp.
	Alder, Green	Alnus crispa
	Alder, Wavy-leaved	Alnus crispa (subspecies of)
	Alder, River	Alnus tenuifolia
	Alder, Sitka	Alnus sinuata
	Bearberry	Arctostaphylos spp.
	Bearberry, Alpine	Arctostaphylos rubra
	Bearberry, Common	Arctostaphylos uva-ursi
	Birch, Dwarf	Betula glandulosa
	Birch, Paper	Betula papyrifera
	Blueberry	Vaccinium myrtilloides
	Buckrush	Symphoricarpos occidentalis
	Buffalo-berry	Sheperdia spp.
	Buffalo-berry, Canadian	Sheperdia canadensis
	Buffalo-berry, Thorny	Shepherdia argentea
	Caragana, (Common)	Caragana arborescens

Common Names	Scientific Names
Cherry, Choke	Prunus virginiana
Cherry, Pin	Prunus pensylvanica
Crabapple, Siberian	Malus baccata
Cranberry, Bog	Vaccinium vitis-idaea
Cranberry, High-bush	Viburnum trilobum
Cranberry, Low-bush	Viburnum edule
Dogwood (Red Osier)	Cornus stolonifera
Douglas Fir	Pseudotsuga menziesii
Dryad	Dryas spp.
Dryad, White	Dryas hookeriana
	Dryas integrifolia
Dryad, Yellow	Dryas drummondii
Elder, Red	Sambucus pubens
Fir, Alpine	Abies lasiocarpa
Fir, Balsam	Abies balsamea
Hawthorn	Crataegus spp.
Hawthorne, Black	Crataegus douglasii
Hazelnut, (Beaked)	Corylus cornuta
Heaths	Ericaceae
Juniper	Juniperus spp.
Juniper (Rocky Mountain)	Juniper scopulorum
Juniper, Creeping	Juniperus horizontalis
Juniper, Ground	Juniperus communis
Labrador tea	Ledum spp.
Larch, Alpine	Larix lyallii
Larch, Western	Larix occidentalis
Tamarack (Larch)	Larix laricina
Mahogany, Mountain	Cerrcocarpus montanus
Maple, Mountain	Acer glabrum
Maple, Manitoba	Acer negundo
Meadowsweet, White	Spiraea lucida
Oak, Bur	Quercus macrocarpa
Creeping Mahonia	Berberis spp.
Pear, Ussurian	Pyrus ussuriensis
Pine	Pinus spp.
Pine, Jack	Pinus banksiana
Pine, Lodgepole	Pinus contorta
Pine, White-bark	Pinus albicaulis
Poplar, Cottonwood	Populus spp.
Poplar, Aspen	Populus tremuloides
Poplar, Balsam	Populus balsamifera
Raspberry	Rubus spp.
Raspberry, Cloudberry	Rubus chamaemorus
Raspberry, Wild Red	Rubus strigosus
Rose	Rosa spp.
Rose, Common Wild	Rosa woodsii
Rose, Hedge	Rosa rugosa
Rose, Prickly	Rosa acicularis

Common Names	Scientific Names
Russian Olive	Elaeagnus angustifolia
Saskatoon	Amelanchier alnifolia
Sea Buckthorn	Hippophae rhamnoides
Silver-berry	Elaeagnus commutata
Snowberry	Symphoricarpos albus
Snow Brush	Ceanothus velutinus
Spruce	Picea spp.
Spruce, Black	Picea mariana
Spruce, Engelmann	Picea engelmannii
Spruce, White	Picea glauca
Willow	Salix spp.
Willow, Arctic	Salix arctica
Willow, Beaked	Salix bebbiana
Willow, Grayleaf	Salix glauca
Grasses and Grass-like Plants	
Barley	Hordeum vulgare
Barley, Foxtail	Hordum jubatum
Bluegrass, Alpine	Poa alpina
Bluegrass, Canada	Poa compressa
Bluegrass, Kentucky	Poa pratensis
Brome	Bromus spp.
Bluejoint	Calamagrostis canadensis
Brome, Awnless	Bromus inermis
Brome, Mountain	Bromus marginatus
Carnary Grass, Reed	Phalaris arundinacea
Fescue	Festuca spp.
Fescue, Red	Festuca rubra
Fescue, Sheep	Festuca ovina
Foxtail, Creeping	Alopecurus arundinaceus
Hair Grass, Tufted	Deschampsia caespitosa
June Grass	Koeleria cristata
Needle Grass	Stipa spp.
Needle Grass, Green	Stipa viridula
Orchard Grass	Dactylis glomerata
Red top	Agrostis alba
Reed Grass, Purple	Clamagrostis purpurascens
Rice Grass, Indian	Oryzopsis hymenoides
Ryegrass	Lolium perenne
Sand Grass	Calamovilfa longifolia
Sweetgrass	Hierochloe alpina
Timothy	Phleum pratense
Timothy, Alpine	Phleum commutatum
Trisetum, Spike	Trisetum spicatum
Wheat Grass	Agropyron spp.
Wheat Grass, Bearded	Agropyron subsecundum
Wheat Grass, Crested	Agropyron cristatum
Wheat Grass, Intermediate	Agropyron intermedium

Common Names	Scientific Names
Wheat Grass, Northern (Elbee)	Agropyron dasystachyum
Wheat Grass, Pubescent	Agropyron trichophorum
Wheat Grass, Slender	Agropyron trachycaulum
Wheat Grass, Streambank	Agropyron riparium
Wheat Grass, Tall	Agropyron elongatum
Wheat Grass, Western	Agropyron smithii
Rye (Wild rye)	Elymus spp.
Wild Rye, Altai	Elymus angustus
Wild Rye, Hairy	Elymus innovatus
Wild Rye, Russian	Elymus junceus

13.2.2 List of Common and Scientific Names of Mammals

Common Names	Scientific Names
Rabbits/Hares	Lagomorpha
American pika	*Ochotona princeps*
Snowshoe hare	*Lepus americana*
Rodents	Rodentia
American beaver	*Castor canadensis*
American red squirrel	*Tamiasciurus hudsonicus*
Bushy-tailed wood rat	*Neotoma cineraNeotoma cinera*
Chipmunk	*Eutamias* spp.
Columbian ground squirrel	*Spermophilus columbianus*
Golden-mantled ground squirrel	*Spermophilus lateralis*
Hoary marmot	*Marmota caligata*
Muskrat	*Ondatra zibethicus*
Carnivores	Carnivora
Bear	*Ursus* spp.
Black bear	*Ursus americanus*
Coyote	*Canis latrans*
Fisher	*Martes pennanti*
Grizzly bear	*Ursus arctos*
Lynx	*Lynx lynx*
Marten	*Martes americanus*
Mink	*Mustel vison*
Red fox	*Vulpes vulpes*
River otter	*Lutra canadensis*
Weasel	*Mustela* spp.
Wolf	*Canis lupus*
Ungulates	Artiodactyla
Bighorn sheep	*Ovis canadensis*
Caribou	*Ranifer tarandus*
Deer	*Odocoileus* spp.
Elk	*Cervus elaphus*
Moose	*Alces alces*
Mountain goat	*Oreamnos americanus*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*

13.2.3 List of Common and Scientific Names of Birds

Common Names	Scientific Names
Swans,Geese and Ducks	Anatidae
Bufflehead	Bucephala albeola
Falcons	Falconidae
American kestrel	Falco sparerius
Grouse/Ptarmigan	Tetraonidae
Spruce grouse	Canachites canadensis
Ruffed grouse	Bonasa umbellus
White-tailed ptarmigan	Lagopus leucurus
Sharp-tailed grouse	Pediocetus phasianellus
Owls	Strigidae
Screech owl	Otus asio
Saw-whet owl	Aegolius funereus
Barn owl	Tyto alba
Woodpeckers	Picidae
Flickers	Colaptes spp.
Hairy woodpeckers	Dendrocopus villosus
Downy woodpecker	Dendrocopus pubescens
Flycatchers	Tyrannidae
Phoebes	Sayornis spp.
Swallows	Hirundinidae
Chickadees	Paridae
Chickadees	Parus spp.
Nuthatches	Sittidae
Nuthatches	Sitta spp.
Wrens	Troglodytidae
House wren	Troglodytes aedon
Thrushes and Bluebirds	Turdidae
American robin	Turdus migratorius
Bluebirds	Sialia spp.

Volume

2

Jeffrey E. Green
and
Richard E. Salter

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Reclamation of Wildlife Habitat in the Canadian Prairie Provinces

Volume II:
Habitat Requirements of Key Species

RECLAMATION OF WILDLIFE HABITAT IN THE CANADIAN PRAIRIE PROVINCES

VOLUME II:

HABITAT REQUIREMENTS OF KEY SPECIES

by

Jeffrey E. Green,
and
Richard E. Salter

The Delta Environmental Management Group Ltd.
Calgary, Alberta

for

Canadian Wildlife Service,
Environmental Protection Service,
and
Recreation, Parks and Wildlife Foundation.

January 1987

PREFACE

The following two volume report represents the first phase of a two-part study on reclamation of wildlife habitat in the prairie provinces of Canada. The report consists of a synthesis of existing technical information on approaches to and methods for reclamation of wildlife habitat (Volume I), and a review of the habitat requirements of key wildlife species for reclamation in the Mountain, Foothill, Boreal Forest and Aspen Parkland biomes within the Canadian Prairie provinces. As a result of funding limitations, the Prairie Grassland biome was not included in the Phase I study.

The second phase of the study involves the compilation of a concise, illustrated manual on reclamation of wildlife habitat. Methods of planning and implementation of wildlife habitat reclamation for all major biomes, including the Prairie Grassland biome, are described.

Funding for both phases of the study has been provided by the Alberta Recreation Parks and Wildlife Foundation, the Western Region of the Canadian Wildlife Service and the Western and Northern Region of the Environmental Protection Service.

PREFACE

Le présent rapport en deux volumes constitue le premier de deux volets d'une étude portant sur la restauration d'habitats fauniques dans les provinces des Prairies au Canada. Il fait la synthèse des données techniques qui ont été recueillies sur les formules et les méthodes de restauration des habitats fauniques (volume I) et donne un aperçu des besoins et des principales espèces fauniques en matière d'habitat pour la restauration des biomes, comme ceux des montagnes, des contreforts, de la forêt boréale et de la forêt-pré à trembles, situés dans la région des Prairies canadiennes. En raison de ressources financières limitées, le biome des Prairies n'a pu être inclus dans la première étape de l'étude.

Le deuxième volet a consisté en l'élaboration d'un bref guide illustré sur a restauration des habitats fauniques. On y explique les méthodes de planification et de mise en oeuvre de la restauration des principaux biomes, y compris celui des Prairies.

Les deux volets de l'étude ont été financés par l'Alberta Recreation, Parks and Wildlife Foundation, le Service canadien de la faune (région de l'Quest) et le Service de la protection de l'environnement (région de l'Quest et du Nord).

ACKNOWLEDGEMENTS

The compilation and synthesis of information in this report has involved the input and assistance of a large number of people. We would like to thank all of the individuals interviewed during this study for their time and cooperation. We would particularly like to thank G. Trottier, B. Munson, and K. Yonge for their continued input, support and direction. We also would like to thank the Coal Association of Canada, the Alberta Fish and Wildlife Division and the Reclamation Research Technical Advisory Committee (Alberta Energy and Natural Resources) for permitting us to extract several sections of the Wildlife Habitat Reclamation report for the Mountain-Foothills Reclamation Research Program for use in this synthesis. We would like to acknowledge J. Stelfox, E. Telfer and G. Trottier for their reviews of earlier versions of this report and K. Smyth for her assistance in compiling this report and editorial review. We also would like to thank A. Carriere for preparation of the typescript.

At the beginning of the study, the authors of the Phase I reports were employed by LGL Limited, environmental research associates in Calgary, Alberta. Although a corporate change by this company resulted in the transfer of this project to the newly-formed Delta Group, we gratefully acknowledge the support of the senior management of LGL Limited in the early development of the project concept and data assimilation.

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1.0 INTRODUCTION

This volume provides details of the methodology used in choosing key wildlife species for the Boreal Forest, Aspen Parkland, and Mountain and Foothill biomes, followed by syntheses of available information on forage selection and the use of cover, terrain, space and special habitat features by each of the key species selected. Existing literature reviews and habitat models relevant to each of the species also are identified. Common names, when available, are used throughout the text in order to improve readability; a list of equivalent scientific names is provided in Appendix 1.

2.0 METHODS

2.1 SELECTION OF KEY SPECIES

Key species were selected separately for the Boreal Forest and Aspen Parkland biomes, and for the Mountain and Foothill biomes combined, based on the four step system described below:

2.1.1 Step 1: Identification of Candidate Species

In order to keep the number of candidate species within reasonable limits, we restricted our evaluations to terrestrial and aquatic mammals and to waterbirds, upland game birds and raptors, and within these groups to species whose population ranges, as described by Banfield (1974) and Salt and Salt (1976), respectively, extended well into the biomes under consideration. Because the original Terms of Reference for this study applied specifically to Alberta, only species occurring within the province were included. Other wildlife groups (e.g., bats, passerine birds) were excluded primarily because their largely specialized habitat requirements were considered to make them poor candidates as representative species.

2.1.2 Step 2: Identification of Species Associations

Species associations, consisting of species with similar habitat requirements, were developed separately for birds and mammals. The tabulation of species groups with similar habitat requirements was based on division of each of the major vegetation communities into five strata (tree canopy, shrub canopy, ground surface, emergent zone/shoreline and open water), and subsequent listing of each species identified in Step 1 under those vegetation strata used to satisfy food, cover and reproductive requirements (Tables 1-6)[1]. Habitat use data for mammals were obtained from Soper (1964) and Banfield (1974), and for birds from Godfrey (1966) and Salt and Salt (1976).

2.1.3 Step 3: Evaluation of Species Significance

The species evaluation system developed by Green et al. (1984) was used in this study, with slight modifications, to provide a systematic method of selecting the most appropriate key species from each species association. Four criteria were used to assess the relative importance of each species:

1. Political importance. Political importance was assessed on the basis of relative abundance and degree of management concern expressed about the species. A value of 0 reflects a high degree of abundance and low management concerns; 1 represents widespread declining numbers (except in cyclic species), or local rarity and moderate management concerns; and 2 indicates a rare, endangered or threatened species with high management concerns.

2. Economic importance. Assessment of economic importance was based both on a species' commercial value (e.g., income provided from fur harvest or from guiding) and subsistence value (meat). For both components, values of 0, 1, or 2 were used to reflect importance, 0 being assigned to species of little or no importance, 1 to species that are occasionally utilized, and 2 to species that are frequently utlilized.

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[1] Because of the large number of tables in this Section, all tables are presented after page 4.

3. Recreational importance. The degrees of both nonconsumptive and consumptive use were considered in the evaluation of each species' recreational importance. Species that commonly support high nonconsumptive use (e.g., bird-watching, photography) received scores of 2. Those with high aesthetic value also scored highly in this category, regardless of their degree of nonconsumptive use (e.g., peregrine falcons are included in this category because they have a high aesthetic value, even though they are infrequently seen by most people). Under consumptive use, game species were assigned values of 0, 1 or 2, with 0 being assigned to non-hunted species, 1 to species of moderate importance to recreational hunting (e.g., snowshoe hare), and 2 to species that are highly important to recreational hunting (e.g., waterfowl, ungulates).

4. Ecological factors. The ecological criterion consisted of two components. The first, ecological importance, refers to the degree to which a species is involved in or contributes to nutrient cycling, the food chain, and physical maintenance of its ecological community. For example, snowshoe hare in sufficient numbers provide an important food source for a variety of predators (particularly lynx) and may contribute significantly to nutrient cycling through browsing activity. Because all species influence ecosystems to some degree, the lowest score assigned was 1. A score of 2 reflects a high degree of interaction within the system and/or a large role in governing or maintaining the system (e.g., because of the direct contribution of beaver and muskrat to the physical maintenance of some wetland areas and their importance as prey species, each would receive a rating of 2). The second component of the ecological criterion, vulnerability to habitat alteration, was scored as 0, 1, or 2 (low, moderate and high vulnerability respectively). This rating was based on a species' dependence on specific habitats and its ability to utilize alternate habitat types in the event of habitat destruction or modification.

5. Additional scoring factors. Two additional factors that are entirely artificial, but that reflect our ability to adequately and expediently evaluate habitat suitability for a given species, were considered. Species for which detailed habitat relationships are known, and for which a habitat model already exists, would, for obvious reasons, be preferred as evaluation species. The availability of habitat-related literature was scored for each species as 0 (little or none), 1 (moderate) or 2 (abundant), while the availability of a model was scored as either 0 (no model available) or 1.

2.1.4 Step 4: Selection of Guild Representatives

The final step in the selection of key species was based on total importance scores (Tables 7-12), the highest scoring species from each association being selected as the representative key species (Tables 13-15). In the event of a tie within an association, the species considered most appropriate as a key species from an ecological or reclamation perspective was selected. (In the latter regard all carnivorous mammals, which were included in the guilding process up to this point because of their socioeconomic and ecological importance, were excluded from consideration as key species because their distributions are affected primarily by prey abundance as opposed to reclaimable habitat features (e.g., vegetation or terrain); however, because of this relationship, reclamation plans for some herbivores would also be expected to benefit some carnivores.) It should be noted that some of the key species represent two or more biomes, and/or two or more habitat strata within a biome.

2.2 LITERATURE REVIEW

General literature reviews of habitat requirements and formal habitat models already exist for many of the key species. Rather than repeat the information contained in these, we focused our literature review on data developed directly within the Boreal Forest, Aspen Parkland, Mountain and Foothill biomes. Data on habitat requirements of key species were culled from a number of sources, ranging from single and multiple-species studies undertaken by university, federal/provincial government or other researchers, to annotated lists of birds and mammals developed for various areas of the province. The review primarily emphasized data developed within Alberta but information from other parts of western Canada, and occasionally from other parts of North America, was also reviewed and incorporated in the species accounts when data specific to provincial biomes were lacking.

Our approach to synthesizing the available information on habitat requirements has been to describe the range of conditions presently occupied by each key species, with the aim of identifying, where possible, the optimal values of various habitat features. Because reclamation is a structuring or building process, habitat requirements of each key species have been summarized largely in structural terms (i.e., general landform type, and slope and aspect of terrain; vegetation community composition and structure; and size, shape and juxtaposition of habitat units). Functional determinants of habitat use (food species selection, use of space, use of cover and shelter, response to human/mechanical disturbance) also were reviewed in order to provide an understanding of how each species uses available habitat.

Table 1. Guilding matrix for the selection of key species of mammals in the Boreal Forest biome.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Tree canopy	Beaver Porcupine Fisher	Red squirrel N.flying squirrel Porcupine Marten Fisher Caribou	Red squirrel N.flying squirrel Beaver Marten Fisher Porcupine	N/A	N/A	Red squirrel Marten Fisher Caribou	N/A	N/A
Shrub canopy	Snowshoe hare L.chipmunk Beaver Deer mouse G.red-b.vole Porcupine Black bear Fisher Mule deer White-t.deer Moose	Snowshoe hare L.chipmunk Deer mouse G.red-b.vole Heather vole Porcupine Black bear Fisher Caribou Mule deer Moose	Snowshoe hare L.chipmunk Beaver Deer mouse G.red-b.vole Heather vole Porcupine Black bear Fisher Mule deer White-t.deer Moose	Snowshoe hare L.chipmunk Beaver Deer mouse G.red-b.vole Heather vole Porcupine Black bear Caribou Mule deer White-t.deer Moose	Snowshoe hare Deer mouse Mule deer White-t.deer	Snowshoe hare G.red-b.vole Heather vole Porcupine Black bear Fisher Caribou Moose	N/A	N/A
Ground surface	Shrews Snowshoe hare L.chipmunk Woodchuck Deer mouse G.red-b.vole Porcupine	Shrews Snowshoe hare L.chipmunk Woodchuck Red squirrel Deer mouse G.red-b.vole	Shrews Snowshoe hare L.chipmunk Woodchuck Red squirrel Deer mouse G.red-b.vole	Shrews Snowshoe hare L.chipmunk Deer mouse G.red-b.vole Heather vole	Shrews Snowshoe hare Woodchuck Deer mouse N.bog lemming Meadow vole Chestnut-c.	Shrews Snowshoe hare Red squirrel G.red-b.vole N. bog lemming Heather vole	N/A	N/A

..... Table 1 continued

Table 1 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST ˙	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Ground surface continued	Coyote Wolf Black bear Fisher Ermine L.weasel S.skunk Lynx Mule deer White-t.deer	Heather vole Porcupine Wolf Black bear Marten Fisher Ermine L.weasel Wolverine S.skunk Lynx Mule deer	Heather vole vole Chestnut-c. vole Meadow jump. mouse Porcupine Coyote Wolf Red fox Black bear Marten Fisher Ermine L.weasel Wolverine S.skunk Lynx Mule deer White-t.deer	Chestnut-c. vole Meadow jump. mouse Porcupine Coyote Wolf Red fox Black bear Ermine L. weasel Lynx Caribou Mule deer White-t.deer	vole Meadow jump. mouse Coyote Red fox Ermine L.weasel Badger S.skunk Mule deer White-t.deer	Chestnut-c. vole Meadow jump. mouse Red fox Black bear Fisher Ermine Mink Wolverine Lynx Caribou		
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	N/A	Water shrew Beaver N.bog lemming Muskrat Mink R.otter Moose	Water shrew Beaver N.bog lemming Muskrat Mink R.otter Moose

..... Table 1 continued

Table 1 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Open Water	N/A	N/A	N/A	N/A	N/A	N/A	Beaver Muskrat R. otter Moose	Beaver Muskrat R. otter Moose

Table 2. Guilding matrix for the selection of key species of birds in the Boreal Forest biome.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Tree canopy	G.blue heron Common g'eye Bufflehead C.merganser Goshawk Sharp-sh. hawk Red-t. hawk Broad-w. hawk Bald eagle Osprey Merlin Kestrel Ruffed grouse Solitary sandpiper G.horned owl G.gray owl Long-eared owl Saw-whet owl	Common g'eye Bufflehead C.merganser Bald eagle Osprey Merlin Kestrel Spruce grouse Solitary sandpiper G.horned owl Hawk owl Barred owl G.gray owl Boreal owl	G.blue heron Common g'eye Bufflehead C.merganser Goshawk Sharp-sh. hawk Red-t. hawk Broad-w. hawk Bald eagle Osprey Merlin Kestrel Ruffed grouse Solitary sandp. G.horned owl Hawk owl Barred owl G.gray owl Long-eared owl Boreal owl Saw-whet owl	N/A	N/A	Common g'eye Bufflehead C.merganser Spruce grouse Solitary sandpiper Bonaparte's gull Hawk owl G.gray owl	N/A	N/A
Shrub canopy	Merlin	Merlin Ruffed grouse	Merlin	Swainson's hawk	N/A	N/A	N/A	N/A
Ground surface	Ruffed grouse Sharp-t. grouse	Spruce grouse Greater y'legs	Ruffed grouse	Canada goose Mallard Gadwall	Canada goose Mallard Gadwall	Green-w. teal Marsh hawk	N/A	N/A

..... Table 2 continued

Table 2. continued

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Ground surface continued	Gray partridge	Lesser y'legs		Pintail Green-w. teal Blue-w.teal Am.wigeon N.shoveler Wh.-w.scoter Red-t. hawk Marsh hawk Merlin Sharp-t.grouse Gray partridge Short-eared owl	Pintail Green-w.teal Blue-w.teal Am.wigeon N.shoveler Lesser scaup Red-t. hawk Golden eagle Marsh hawk Merlin Kestrel Sharp-t.grouse Gray partridge Sandhill crane Yellow rail Killdeer Common snipe Upland sandpiper Spotted sandpiper W.phalarope California gull Ring-billed gull Franklin's gull Short-eared owl	Spruce grouse Sharp-t. grouse Sandhill crane Common snipe Greater y'legs Lesser y'legs S.-b.dowitcher Hawk owl		
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	N/A	Common loon Red-n.grebe Horned grebe Eared grebe West. grebe Pied-billed grebe	Wt.pelican Dbl-cr cormorant G.blue heron Am.bittern Mallard Gr.w.teal

..... Table 2 continued

Table 2 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Emergent zone/ shoreline continued							Wt. pelican Dbl-cr cormorant G.bl. heron Am.bittern Can. goose Mallard Gadwall Pintail Gr.-w.teal Blue-w.teal Am.wigeon N.shoveler Redhead Ring-n.duck Canvasback Less scaup Com. g'eye Bufflehead Ww.scoter Surf scoter Ruddy duck Bald eagle Osprey Sdhill crane Virginia rail Sora Yellow rail American coot Killdeer Common snipe Spotted sandpiper	Lesser scaup Bald eagle Osprey Virginia rail Sora Amer. coot Killdeer Com. snipe Spotted sandpiper Sol sandp. Grt y'legs Les. y'legs S. dowitcher W.phalarope Herring gull Calif. gull Ring-b. gull Frankl. gull Com. tern Black tern Short-eared owl Belted kingfisher

..... Table 2 continued

Table 2 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Emergent zone/ shoreline continued							Solitary sandpiper Greater y'legs Lesser y'legs S.-b.dowitcher W.phalarope Herring Gull California gull Ring-b. gull Franklin's gull Common tern Black tern Short-eared owl Belted kingfisher	
Open water	N/A	N/A	N/A	N/A	N/A	N/A	Com. loon Red-n.grebe Hrnd grebe Eared grebe West. grebe P.b.grebe Wt. pelican Dbl.cr. cormorant Can. goose Mallard Gadwall Pintail G.w.teal Blue-w.teal Am.wigeon N.shoveler Redhead	Wt. pelican Dbl.cr. cormorant Can. goose Mallard G.w.teal Blue-w.teal Lesser scaup Com. g'eye Bufflehead C.merganser Bald eagle Osprey Amer. coot Herring gull Calif. gull Ring-b.gull Bonaparte's

..... Table 2 continued

Table 2 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Open water continued							Ring-n.duck Canvasback Less. scaup Com. g'eye Bufflehead W.w.scoter Surf scoter Ruddy duck C.merganser Bald eagle Osprey American coot W.phalarope Herring gull California gull Ring-b.gull Bonaparte's gull Common tern Black tern Belted kingfisher	gull Com. tern Black tern Belted kingfisher

Table 3. Guilding matrix for the selection of key species of mammals in the Aspen Parkland biome.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Tree canopy	Beaver Porcupine Raccoon	Red squirrel N.fly squirrel Porcupine Raccoon	Red squirrel N.fly squirrel Beaver Porcupine Raccoon	N/A	N/A	N/A	N/A
Shrub canopy	Snowshoe hare L.chipmunk Beaver Deer mouse G.red-b.vole Porcupine Mule deer White-t.deer	Snowshoe hare L.chipmunk Deer mouse G.red-b.vole Porcupine Mule deer	Snowshoe hare L.chipmunk Beaver Deer mouse G.red-b.vole Porcupine Mule deer White-t.deer	Snowshoe hare W-t.jackrabbit L.chipmunk Beaver Deer mouse G.red-b.vole W.jump.mouse Porcupine Mule deer White-t.deer	Snowshoe hare W-t.jackrabbit Deer mouse Mule deer White-t.deer	N/A	N/A
Ground surface	Shrews Snowshoe hare L.chipmunk Woodchuck Thirteen-line. grd. squirl. F.grd. squirl. Deer mouse G.red-b.vole W.jump.mouse Porcupine Coyote Raccoon Ermine Long-t.weasel	Shrews Snowshoe hare L.chipmunk Woodchuck Red squirrel Deer mouse G.red-b.vole Porcupine Raccoon Ermine Least weasel Striped skunk Mule deer	Shrews Snowshoe hare L.chipmunk Woodchuck Red squirrel Deer mouse G.red-b.vole W.jump.mouse M.jump.mouse Porcupine Coyote Red fox Raccoon Ermine Least weasel	Shrews Snowshoe hare W-t.jackrabbit L.chipmunk Thirteen-line. grd. squirl. F.grd. squirl. Deer mouse G.red-b.vole Prairie vole W.jump.mouse M. jump mouse Porcupine Coyote Red fox	Shrews Snowshoe hare W-t.jackrabbit Woodchuck Rch.grd.squirl. Thirteen-line grd. squirl. F.grd. squirl. N.pocket gopher Deer mouse Prairie vole Meadow vole W.jump.mouse M.jump.mouse Coyote	N/A	N/A

. Table 3 continued

Table 3 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Ground surface continued	Least weasel Striped skunk Mule deer White-t.deer		Striped skunk Mule deer White-t.deer	Ermine Long-t.weasel Least weasel Mule deer White-t.deer	Red fox Ermine Long-t.weasel Least weasel Badger Striped skunk Mule deer White-t.deer		
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	F.grd. squirl. Beaver Muskrat	F.grd. squirl. Beaver Muskrat
Open water	N/A	N/A	N/A	N/A	N/A	Beaver Muskrat	Beaver Muskrat

Table 4. Guilding matrix for the selection of key species of birds in the Aspen Parkland biome.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Tree canopy	G.blue heron Common g'eye Bufflehead C.merganser Goshawk Sharp-sh. hawk Red-t.hawk Broad-w.hawk Cooper's hawk Swain. hawk Merlin Kestrel Ruffed grouse G.horned owl G.gray owl Long-eared owl Saw-whet owl	Common g'eye Bufflehead C.merganser Merlin Kestrel G.horned owl Barred owl G.gray owl Boreal owl	G.blue heron Common g'eye Bufflehead C.merganser Goshawk Sharp-sh. hawk Red-t. hawk Broad-w. hawk Cooper's hawk Merlin Kestrel Ruffed grouse G.horned owl Barred owl G.gray owl Long-eared owl Boreal owl Saw-whet owl	N/A	N/A	N/A	N/A
Shrub canopy	Merlin	Merlin Ruffed grouse	Merlin	Swainson's hawk	N/A	N/A	N/A
Ground surface	Ruffed grouse Sharp-t. grouse Gray partridge Ring-necked pheasant		Ruffed grouse	Canada goose Mallard Gadwall Pintail Green-w. teal Blue-w.teal Am.wigeon N.shoveler Wh.-w.scoter	Canada goose Mallard Gadwall Pintail Green-w.teal Blue-w.teal Am.wigeon N.shoveler Lesser scaup	N/A	N/A

..... Table 4 continued

Table 4 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Ground surface continued				Red-t.hawk Marsh hawk Merlin Sharp-t.grouse Ring-necked pheasant Gray partridge Short-eared owl	Red-t.hawk Swain.hawk Marsh hawk Merlin Kestrel Sharp-t.grouse Gray partridge R.-n.pheasant Yellow rail Killdeer Common snipe Upland sandpiper Spotted sandpiper W.phalarope Willet Marbled godwit California gull Ring-billed gull Franklin's gull Short-eared owl		
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	Red-n.grebe Horned grebe Eared grebe Western grebe Pied-billed grebe Dbl.-cr. cormorant Bk.-crowned night heron G.blue heron Am.bittern Canada goose Mallard	Dbl.-cr cormorant Bk.-crowned night heron G.blue heron Am.bittern Mallard Green-w.teal Lesser scaup R.-n.pheasant Virginia rail Sora American coot Killdeer

..... Table 4 continued.

Table 4 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Emergent zone/ shoreline continued						Gadwall Pintail Green-w.teal Blue-w.teal Am.wigeon N.shoveler Redhead Ruddy duck Canvasback Lesser scaup Common g'eye Bufflehead Wh.-w.scoter Ruddy Duck Ring-necked pheasant Sandhill crane Virginia rail Sora Yellow rail American coot Piping plover Killdeer Common snipe Spotted sandpiper Marbled godwit Am.avocet W.phalarope California gull Ring-b. gull Forster's tern Black tern Short-eared owl Belted kingfisher	Common snipe Spotted sandpiper Willet W.phalarope California gull Ring-b.gull Franklin's gull Forster's tern Common tern Black tern Belted kingfisher Short-eared owl

..... Table 4 continued

Table 4 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Open water	N/A	N/A	N/A	N/	N/A	Red-n.grebe Horned grebe Eared grebe Western grebe Pied-b.grebe Dbl.-cr. cormorant Canada goose Mallard Gadwall Pintail Green-w.teal Blue-w.teal Am.wigeon N.shoveler Redhead Canvasback Lesser scaup Common g'eye Bufflehead Wh.-w.scoter Ruddy duck C.merganser American coot W.phalarope California gull Ring-b.gull Forster's tern Common tern Black tern Belted kingfisher	Dbl.cr. cormorant Canada goose Mallard Green-w.teal Blue-w.teal Lesser scaup Common g'eye Bufflehead C.merganser American coot California gull Ring-billed gull Forster's tern Common tern Black tern Belted kingfisher

Table 5. Guilding matrix for the selection of key species of mammals in the Mountain and Foothill biomes.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Tree canopy	N.flying squirrel Beaver Porcupine	Red squirrel N.fly squirrel Wood rat Porcupine Marten Fisher Mountain lion Caribou	Red squirrel N.fly squirrel Porcupine Marten Fisher	N/A	N/A	Red squirrel Marten Fisher	N/A	N/A	N/A
Shrub canopy	Snowshoe hare L.chipmunk Beaver Deer mouse Wood rat G.red-b.vole Porcupine Black bear Grizzly bear Marten Mule deer White-t.deer Moose Elk	Snowshoe hare L.chipmunk Pine chipmunk Wood rat G.red-b.vole Porcupine Marten Caribou Mule deer White-t.deer Moose Elk	Snowshoe hare L.chipmunk Pine chipmunk Beaver Deer mouse Wood rat G.red-b.vole Porcupine Black bear Grizzly bear Marten Caribou Mule deer White-t.deer Moose Elk	Snowshoe hare L.chipmunk Beaver Deer mouse Wood rat G.red-b.vole W.jumping mouse Porcupine Black bear Grizzly bear Mule deer White-t.deer Moose Elk	Hoary marmot Columbian grd. squirrel Elk	Snowshoe hare Deer mouse N.bog lemming Heather vole Porcupine	Pika Hoary marmot	N/A	N/A
Ground surface	Shrews Snowshoe hare L.chipmunk Red squirrel Deer mouse	Shrews Snowshoe hare L.chipmunk Red squirrel Deer mouse	Shrews Snowshoe hare L.chipmunk Red squirrel Deer mouse	Shrews Snowshoe hare Hoary marmot Col.grd squirrel Golden-mantled	Shrews Pika Hoary marmot Col.grd squirrel Golden-mantled	Shrews Snowshoe hare N.bog lemming Wolf Red fox	Pika Hoary marmot Wood rat Heather vole Grizzly bea	N/A	N/A

Table 5 continued

Table 5 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Ground surface continued	G.red-b.vole W.jump.mouse Porcupine Coyote Wolf Red fox Black bear Grizzly bear Weasel Mink Striped skunk Lynx Bobcat Mule deer White-t.deer Moose Elk	G.red-b.vole Wolf Black bear Weasel Mink Mountain lion Lynx Bobcat Caribou	G.red-b.vole W.jump.mouse Porcupine Coyote Wolf Red fox Weasel Mink Striped skunk Mountain lion Lynx Bobcat Mule deer White-t.deer Moose Elk	..grd squirrel Deer mouse G.red-b.vole Heather vole Porcupine Coyote Wolf Red fox Black bear Grizzly bear Weasel Mink Wolverine Badger Lynx Bobcat Mule deer	..grd squirrel N.pocket gopher Deer mouse Wood rat N.bog lemming Heather vole Meadow vole Long-tailed vole W.jump.mouse Coyote Red fox Black bear Grizzly bear Weasel Wolverine Badger Striped skunk Mule deer Elk Mountain goat Bighorn sheep	Weasel Mink Lynx	Wolverine Mountain goat Bighorn sheep		
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Water shrew Beaver Muskrat Rich.water vole Mink River otter Moose	Water shrew Beaver Muskrat Rich.water vole Mink River otter Moose
Open water	N/A	N/A	N/A	N/A	N/A	N/A	N/A	River otter Beaver	River otter

Table 6. Guilding matrix for the selection of key species of birds in the Mountain and Foothill biomes.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Tree canopy	Common g'eye Barrow's g'eye Bufflehead H.merganser C.merganser Goshawk Sharp-sh. hawk Cooper's hawk Red-t. hawk Bald eagle Osprey Merlin Kestrel Ruffed grouse Solitary sandpiper G.horned owl G.gray owl Saw-whet owl	Common g'eye Barrow's g'eye Bufflehead H.merganser C.merganser Bald eagle Osprey Merlin Kestrel Blue grouse Spruce grouse Ruffed grouse White-tailed ptarmigan Solitary sandpiper G.horned owl Hawk Owl Pygmy owl Barred owl G.gray owl Boreal owl Saw-whet owl	Common g'eye Bufflehead H.merganser C.merganser Goshawk Sharp-sh. hawk Cooper's hawk Red-t. hawk Bald eagle Osprey Merlin Kestrel Ruffed grouse White-tailed ptarmigan Solitary sandpiper G.horned owl Hawk Owl Pygmy owl Barred owl G.gray owl	N/A Barrow's g'eye	N/A	Common g'eye Bufflehead H.merganser C.merganser Spruce grouse Solitary sandpiper Hawk Owl G.gray owl Saw-whet owl	N/A Barrow's g'eye	N/A	N/A
Shrub canopy	Merlin Ruffed grouse	Merlin	Merlin	N/A	N/A	N/A	White-tailed ptarmigan	N/A	N/A
Ground surface	Blue grouse Ruffed grouse Sharp-tailed	Spruce grouse Greater y'legs Lesser y'legs	Ruffed grouse	Canada goose Mallard Pintail	Canada goose Mallard Pintail	Green-w.teal Spruce grouse Sharp-tailed	Golden eagle White-tailed ptarmigan	N/A	N/A

..... Table 6 continued

Table 6 continued

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Ground surface continued	grouse			Green-w.teal Blue-w.teal N.shoveler Marsh hawk Sharp-tailed grouse	Green-w.teal Blue-w.teal N.shoveler Lesser scaup Marsh hawk Blue grouse White-t. ptarmigan Sharp-t. grouse Killdeer Common snipe Spotted sandpiper	grouse Common snipe Greater y'legs Lesser y'legs			
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Common loon R.-necked grebe Canada goose Mallard Pintail Green-w.teal Blue-w.teal N.shoveler Lesser scaup Common g'eye Barrow's g'eye Bufflehead Harlequin duck Sora American coot Killdeer Common snipe Spotted sandpiper Solitary sandpiper	Canada goose Mallard Blue-w.teal Green-w.teal Lesser scaup Harlequin duck Sora American coot Killdeer Common snipe Spotted sandpiper Solitary sandpiper Greater y'legs Lesser y'legs

..... Table 6 continued

Table 6 concluded.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Emergent zone/ shoreline								Greater y'legs Lesser y'legs	
Open water								Common loon Red-neck grebe Canada goose Mallard Pintail Green-w.teal Blue-w.teal N.shoveler Lesser scaup Common g'eye Barrow's g'eye Bufflehead Harlequin duck H.merganser C.merganser American coot	Canada goose Mallard Green-w.teal Blue-w.teal Lesser scaup Common g'eye Barrow's g'eye Bufflehead Harlequin duck H.merganser C.merganser American coot

Table 7. Assignment of importance values for selection of key species of mammals in the Boreal Forest biome.

	Masked shrew	Dusky shrew	Water shrew	Arctic shrew	Pigmy shrew	Snowshoe hare	Least chipmunk	Woodchuck	Red squirrel	Northern flying squirrel	Beaver	Deer mouse	Gapper's red-backed vole	Northern bog lemming	Heather vole	Muskrat	Meadow vole	Chestnut-cheeked vole	Meadow jumping mouse	Porcupine	Coyote	Wolf	Red fox	Black bear	Marten	Fisher	Ermine	Least weasel	Mink	Wolverine	Striped skunk	River otter	Lynx	Caribou	Mule deer	White-tailed deer	Moose
Political Importance																																					
Status and Manage.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Economic Importance																																					
Commercial Value	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	2	0	0	0	0	1	1	1	1	2	1	1	0	2	2	0	2	2	0	0	0	0
Subsistence Value	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	2
Recreational Importance																																					
Consumptive	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	2	2	2	2
Non-consumptive	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	1	0	0	0	1	1	2	1	2	1	1	1	1	1	1	1	2	2	2	2	2	2
Ecological Aspects																																					
Importance	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Vulnerability	0	0	1	0	0	0	0	0	0	1	2	0	0	1	1	2	0	0	0	0	0	0	0	0	1	1	0	0	2	1	0	1	0	2	0	0	1
Additional Considerations																																					
Literature Avail.	0	0	0	0	0	2	1	1	2	0	2	2	2	0	0	2	2	0	0	1	1	1	1	1	1	0	1	0	1	0	0	1	1	2	2	2	2
Existing Model	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	1	0	1	1	1	0	0	1	0	0	0	1	0	1	1	1
Total Score	1	1	2	1	1	8	3	3	7	2	11	3	4	2	2	12	4	1	1	4	5	8	4	9	7	5	4	2	8	5	2	7	7	11	9	9	12

Table 8. Assignment of importance values for selection of key species of birds in the Boreal Forest biome.

	Common loon	Red-necked grebe	Horned grebe	Eared grebe	Western grebe	Pied-billed grebe	White pelican	Double-crested cormorant	Great blue heron	American bittern	Canada goose	Mallard	Gadwall	Pintail	Green-winged teal	Blue-winged teal	American wigeon	Northern shoveler	Redhead	Ring-necked duck	Canvasback	Lesser scaup	Common goldeneye	Bufflehead	White-winged scoter	Surf scoter	Ruddy duck	Common merganser	Goshawk	Sharp-shinned hawk	Red-tailed hawk	Broad-winged hawk	Golden eagle	Bald eagle	Marsh hawk	Osprey	Merlin	American kestrel	Spruce grouse	Ruffed grouse
Political Importance																																								
Status and Manage.	1	0	0	0	1	0	2	2	2	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	1	1	0	0
Economic Importance																																								
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	0	0	0	0	0	0	0	0	0	2	2	1	2	2	2	2	1	2	1	2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	2	2
Recreational Importance																																								
Consumptive	0	0	0	0	0	0	0	0	0	0	2	2	1	2	2	2	2	1	2	1	2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	2	2
Non-consumptive	1	1	1	1	2	1	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1
Ecological Aspects																																								
Import. to System	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	2	1	1	1	2	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	2	0	2	0	0	0	0
Additional Considerations																																								
Literature Avail.	1	1	0	0	1	0	1	1	1	0	1	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Existing Model	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Total Score	6	4	3	3	7	3	8	8	9	2	9	9	5	7	7	7	7	5	8	5	9	5	6	6	4	4	5	5	3	3	3	3	8	8	3	8	4	4	9	8

..... Table 8 continued

Table 8. continued.

	Sharp-tailed grouse	Gray partridge	Sandhill crane	Virginia rail	Sora	Yellow rail	American coot	Killdeer	Common snipe	Upland sandpiper	Spotted sandpiper	Solitary sandpiper	Greater yellowlegs	Lesser yellowlegs	Short-billed dowitcher	Wilson's phalarope	Herring gull	California gull	Ring-billed gull	Franklin's gull	Bonaparte's gull	Common tern	Black tern	Great horned owl	Hawk owl	Barred owl	Great gray owl	Long-eared owl	Short-eared owl	Boreal owl	Saw-whet owl	Belted kingfisher
Political Importance																																
Status and Manage.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Economic Importance																																
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	2	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recreational Importance																																
Consumptive	2	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-consumptive	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ecological Aspects																																
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional Considerations																																
.Literature Avail.	2	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0
Existing Model	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	10	7	4	2	2	2	5	2	6	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2	2

Table 9. Assignment of importance values for selection of key species of mammals in the Aspen Parkland biome.

	Masked shrew	Snowshoe hare	White-tailed jackrabbit	Least chipmunk	Woodchuck	Richardson's ground squirrel	Thirteen-lined ground squirrel	Franklin's ground squirrel	Red squirrel	Northern flying squirrel	Northern pocket gopher	Beaver	Deer mouse	Gapper's red-backed vole	Muskrat	Prairie vole	Meadow vole	Western jumping mouse	Meadow jumping mouse	Porcupine	Coyote	Red fox	Raccoon	Ermine	Long-tailed weasel	Least weasel	Badger	Striped skunk	Mule deer	White-tailed deer
Political Importance																														
Status and Manage.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Economic Importance																														
Commercial Value	0	0	0	0	0	0	0	0	1	0	0	2	0	0	2	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0
Subsistence Value	0	1	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Recreational Importance																														
Consumptive	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	2
Non-consumptive	0	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2
Ecological Aspects																														
Importance	1	2	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	0	0	0	0	0	0	0	0	0	1	0	2	0	0	2	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Additional Considerations																														
Literature Avail.	0	2	0	1	1	1	1	1	2	0	0	2	2	2	2	0	2	0	0	1	1	1	0	1	1	0	0	0	2	2
Existing Model	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Total Score	1	8	2	3	3	3	3	3	7	2	1	11	3	4	12	1	4	2	1	4	5	4	3	4	4	2	4	2	9	9

Table 10. Assignment of importance values for selection of key species of birds in the Aspen Parkland biome.

	Red-necked grebe	Horned grebe	Eared grebe	Western grebe	Pied-billed grebe	Double-crested cormorant	Great blue heron	Black-crowned night heron	American bittern	Canada goose	Mallard	Gadwall	Pintail	Green-winged teal	Blue-winged teal	American wigeon	Northern shoveler	Redhead	Canvasback	Lesser scaup	Common goldeneye	Bufflehead	White-winged scoter	Ruddy duck	Common merganser	Goshawk	Sharp-shinned hawk	Cooper's hawk	Red-tailed hawk	Broad-winged hawk	Swainson's hawk	Marsh hawk	Merlin	American kestrel	Ruffed grouse	Sharp-tailed grouse	Ring-necked pheasant	Gray partridge	Virginia rail	Sora
Political Importance																																								
Status and Manage.	0	0	0	1	0	2	2	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Economic Importance																																								
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	0	0	0	0	0	0	0	0	2	2	1	2	2	2	2	1	2	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	2	2	1	2	0	0
Recreational Importance																																								
Consumptive	0	0	0	0	0	0	0	0	0	2	2	1	2	2	2	2	1	2	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0
Non-consumptive	1	1	1	2	1	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ecological Aspects																																								
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	1	1	1	2	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Additional Considerations																																								
Literature Avail.	1	0	0	1	0	1	1	0	0	1	2	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	0	0
Existing Model	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Total Score	4	3	3	7	3	8	9	3	2	9	9	5	7	7	7	7	5	8	9	5	6	6	4	5	5	3	3	3	3	3	3	3	4	4	8	10	9	7	2	2

..... Table 10 continued

Table 10. continued.

	Yellow rail	American coot	Piping plover	Killdeer	Common snipe	Upland sandpiper	Spotted sandpiper	Willet	Marbled godwit	American avocet	Wilson's phalarope	California gull	Ring-billed gull	Franklin's gull	Forster's tern	Common tern	Black tern	Great horned owl	Barred owl	Great gray owl	Long-eared owl	Short-eared owl	Boreal owl	Saw-whet owl	Belted kingfisher
Political Importance																									
Status and Manage.	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Economic Importance																									
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recreational Importance																									
Consumptive	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-consumptive	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ecological Aspects																									
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional Considerations																									
Literature Avail.	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Existing Model	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	2	5	8	2	6	3	2	2	2	4	2	2	2	2	2	2	2	3	2	3	2	2	2	2	2

Table 11. Assignment of importance values for selection of key species of mammals in the Mountain and Foothill biomes.

	Masked shrew	Dusky shrew	Water shrew	Arctic shrew	Pigmy shrew	Pika	Snowshoe hare	Least chipmunk	Yellow pine chipmunk	Hoary marmot	Columbian ground squirrel	Golden-mantled ground squirrel	Red squirrel	Northern flying squirrel	Northern pocket gopher	Beaver	Deer mouse	Bushy-tailed wood rat	Gapper's red-backed vole	Northern bog lemming	Heather vole	Muskrat	Richardson's water vole	Meadow vole	Long-tailed vole	Western jumping mouse
Political Importance																										
Status and Management	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Economic Importance																										
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	2	0	0	0	0
Subsistence Value	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0	0	0
Recreational Importance																										
Consumptive Use	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-consumptive Use	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Ecological Aspects																										
Importance to System	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	2	1	1
Vulnerability	0	0	1	0	0	2	0	0	0	1	0	0	0	1	0	2	0	0	0	1	1	2	1	0	0	1
Additional Considerations																										
Availability of Literature	0	0	0	0	0	0	2	1	0	1	2	1	2	0	0	2	2	0	2	0	0	2	0	2	0	0
Existing Model	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1	0	0
Total Score	1	1	2	1	1	4	7	3	2	4	4	3	7	2	1	11	3	1	4	2	2	12	2	5	1	2

	Porcupine	Coyote	Wolf	Red fox	Black bear	Grizzly bear	Marten	Fisher	Ermine	Long-tailed weasel	Least weasel	Mink	Wolverine	Badger	Striped skunk	River otter	Mountain lion	Lynx	Bobcat	Caribou	Mule deer	White-tailed deer	Moose	Elk	Mountain goat	Bighorn sheep
Political Importance																										
Status and Management	0	0		1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	1	2	0	0	0	1	1
Economic Importance																										
Commercial Value	0	1		1	1	1	1	2	1	1	1	0	2	2	1	0	2	0	2	1	0	0	0	0	0	0
Subsistence Value	1	0		0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	0
Recreational Importance																										
Consumptive Use	0	1		0	0	2	2	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2	2	2	2	2
Non-consumptive Use	1	1		2	1	2	2	1	1	0	0	0	1	1	1	0	1	2	2	2	2	2	2	2	2	2
Ecological Aspects																										
Importance to System	1	1		2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	2	2	1
Vulnerability	0	0		0	0	0	1	1	1	0	0	0	2	1	1	0	1	1	0	0	2	0	0	1	1	2
Additional Considerations																										
Availability of Literature	1	1		1	1	1	1	1	0	1	1	0	1	0	0	0	1	0	1	0	2	2	1	2	2	2
Existing Model	0	0		1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0
Total Score	4	5		8	5	9	10	7	5	3	3	1	8	5	4	1	6	7	8	6	12	8	7	12	12	10

Table 12. Assignment of importance values for selection of key species of birds in the Mountain and Foothill biomes.

	Common loon	Red-necked grebe	Canada goose	Mallard	Pintail	Green-winged teal	Blue-winged teal	Northern shoveler	Lesser scaup	Common goldeneye	Barrow's goldeneye	Bufflehead	Harlequin duck	Hooded merganser	Common merganser
Political Importance															
Status and Manage.	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Economic Importance															
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	0	2	2	2	2	2	1	1	1	0	1	0	0	1
Recreational Importance															
Consumptive	0	0	2	2	2	2	2	1	1	1	0	1	0	0	1
Non-consumptive	1	1	2	1	1	1	1	1	1	1	2	1	2	2	1
Ecological Aspects															
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	2	1	0	0	0	0	0	0	0	1	1	1	2	1	0
Additional Considerations															
Literature Avail.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Existing Model	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	6	4	8	7	7	7	7	5	5	6	6	6	7	6	5

	Goshawk	Sharp-shinned hawk	Cooper's hawk	Red-tailed hawk	Golden eagle	Bald eagle	Marsh hawk	Osprey	Merlin	American kestrel	Blue grouse	Spruce grouse	Ruffed grouse	White-tailed ptarmigan	Sharp-tailed grouse
Political Importance															
Status and Manage.	0	0	0	0	2	2	0	2	1	1	0	0	0	1	0
Economic Importance															
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	0	0	0	0	0	0	0	0	0	1	2	2	1	2
Recreational Importance															
Consumptive	0	0	0	0	0	0	0	0	0	0	1	2	2	1	2
Non-consumptive	1	1	1	1	2	2	1	2	1	1	2	1	1	2	1
Ecological Aspects															
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	0	0	0	0	2	2	0	2	1	0	1	0	0	1	0
Additional Considerations															
Literature Avail.	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1
Existing Model	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total Score	3	3	3	3	8	8	3	8	5	4	8	9	8	9	7

	Sora	American coot	Killdeer	Common snipe	Spotted sandpiper	Solitary sandpiper	Greater yellowlegs	Lesser yellowlegs	Great horned owl	Hawk owl	Pygmy owl	Barred owl	Great gray owl	Boreal owl	Saw-whet owl
Political Importance															
Status and Manage.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Economic Importance															
Commercial Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsistence Value	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Recreational Importance															
Consumptive	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Non-consumptive	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Ecological Aspects															
Importance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vulnerability	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional Considerations															
Literature Avail.	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0
Existing Model	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Score	3	4	1	4	1	1	1	1	3	2	2	2	3	2	2

Table 13. Key species selected in each habitat stratum of the Boreal Forest biome.[1]

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Tree canopy	Fisher(5) Beaver(11) G.b.heron(9) Bald eagle/ Osprey(8) Ruf.grouse(8)	Marten(7) Caribou(11) Common g'eye/ Bufl'hd(6) Bald eagle/ Osprey(8) Spr.grouse(9)	Marten(7) Beaver(11) G.b.heron(9) Bald eagle/ Osprey(8) Ruf.grouse(8)	N/A	N/A	Marten(7) Caribou(11) Common g'eye/ Bufl'hd(6) Spr.grouse(9)	N/A	N/A
Shrub canopy	B.bear(9) Moose(12) Merlin(4) Ruf.grouse(8)	B.bear(9) Moose(12) Merlin(4)	B.bear(9) Moose(12) Merlin(4)	B.bear(9) Moose(12)	Mule deer/ W.-t.deer(9)	B.bear(9) Moose(12)	N/A	N/A
Ground surface	B.bear(9) Mule deer/ W.-t.deer(9) Sharp-t. grouse(10)	B.bear(9) Mule deer(9) Spr.grouse(9) Greater/ Lesser y'legs(2)	B.bear(9) Mule deer/ W.-t.deer(9) Ruf.grouse(8)	B.bear(9) Caribou(11) Can.goose/ Mallard(9 Merlin(4) Sharp-t. grouse(10)	Coyote(5) Mule deer/ W.-t.deer(9) Can.goose/ Mallard(9) G.eagle(8) Sharp-t. grouse(10)	B.bear(9) Caribou(11) G.-w.teal(7) Marsh hawk(3) Sharp-t. grouse(10)	N/A	N/A
Emergent zone/ ..shoreline	N/A	N/A	N/A	N/A	N/A	N/A	Mink(8) Muskrat/ Moose(12) G.b.hero N/ Can.goose/ Mallard/	Mink(8) Muskrat/ Moose(12) G.b.hero N/ Mallard(9) Bald eagle/

..... Table 13 continued

Table 13 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	LACUSTRINE	RIVERINE
Emergent zone/ shoreline							Canvasback(9) Bald eagle/ Osprey(8)	Osprey(8)
Open water	N/A	N/A	N/A	N/A	N/A	N/A	R.otter(7) Muskrat/ Moose(12) Can.goose/ Mallard/ Canvasback(9) Bald eagle/ Osprey(8)	R.otter(7) Muskrat/ Moose(12) Can.goose/ Mallard(9) Bald eagle/ Osprey(8)

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[1] The highest scoring carnivore, herbivore, waterbird, raptor and upland gamebird species in each stratum are listed for purposes of comparison. The key species selected for each stratum is underlined.

Table 14. Key species selected in each habitat stratum of the Aspen Parkland biome.[1]

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Tree stratum	Raccoon(3) Beaver(11) G.b.heron(9) Merlin/Kestrel(4) Ruf.grouse(8)	Raccoon(3) R.squirrel(7) Common g'eye/Bufflehead(6) Merlin/Kestrel(4)	Raccoon(3) Beaver(11) G.b.heron(9) Merlin/Kestrel(4) Ruf.grouse(8)	N/A	N/A	N/A	N/A
Shrub canopy	Beaver(11) Merlin(4) Ruf.grouse(8)	Mule deer(9) Merlin(4)	Beaver(11) Merlin(4)	Beaver(11) Swainson's hawk(3)	Mule deer/W.-t.deer(9)	N/A	N/A
Ground surface	Coyote(5) Mule deer/W.-t.deer(9) Sharp-t. grouse(10)	Ermine(4) Mule deer(9)	Coyote(5) Mule deer/W.-t.deer(9) Ruf.grouse(8)	Coyote(5) Mule deer/W.-t.deer(9) Can.goose/Mallard(9) Merlin(4) Sharp-t. grouse(10)	Coyote(5) Mule deer/W.-t.deer(9) Can.goose/Mallard(9) G.eagle(8) Sharp-t. grouse(10)	N/A	N/A
Emergent zone/shoreline	N/A	N/A	N/A	N/A	N/A	Muskrat(12) G.b.heron/Can.goose/Mallard(9) Ring-necked pheasant(9)	Muskrat(12) G.b.heron/Mallard(9) Ring-necked pheasant(9)

..... Table 14 continued

Table 14 continued.

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	LACUSTRINE	RIVERINE
Open water	N/A	N/A	N/A	N/A	N/A	Muskrat(12) Can.goose/ Mallard/ Canvasback(9)	Muskrat(12) Can.goose/ Mallard(9)

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[1] The highest scoring carnivore, herbivore, waterbird, raptor and upland gamebird species in each stratum are listed for purposes of comparison. The key species selected for each stratum is underlined.

Table 15. Key species selected in each habitat stratum of the Mountain and Foothill biomes.[1]

STRATUM	DECIDUOUS FOREST	CONIFEROUS FOREST	MIXED FOREST	SHRUBLAND	MEADOW	BOG/ MUSKEG	TALUS/ CLIFF	LACUSTRINE	RIVERINE
Tree canopy	Beaver(11) Tree ducks(6) Bald eagle/Osprey(8) Ruf.grouse(8)	Mountain lion/Marten(7) Caribou(12) Tree ducks(6) White-tailed ptarmigan(9) Bald eagle/Osprey(8)	R.squirrel(7) Marten(7) Tree ducks(6) Bald eagle/Osprey(8) White-tailed ptarmigan(9)	N/A	N/A	R.squirrel(7) Marten(7) Tree ducks(6) Spr.grouse(8) G.gray owl(3)	N/A	N/A	N/A
Shrub canopy	G.bear(10) Moose/Elk(12) Merlin(5) Ruf.grouse(8)	Marten(7) Caribou/Moose/Elk(12) Merlin(5)	G.bear(10) Caribou/Moose/Elk(12) Merlin(5)	G.bear(10) Moose/Elk(12)	Elk(12)	S.hare(7)	Pika/Hoary marmot(4) W.-t.ptarmigan(9)	N/A	N/A
Ground surface	G.bear(10) Moose/Elk(12) Blue/Ruffed grouse(8)	Wolf(8) Caribou(12) Spr.grouse(8) Greater/Lesser y'legs(1)	Wolf(8) Moose/Elk(12) Ruf.grouse(8)	G.bear(10) Elk(12) Can.goose(8) Merlin(5) S.-t.grouse(7)	G.bear(10) Elk(12) Can.goose(8) G.eagle(8) W-t.ptarm.(9)	S.hare(7) Mink/Lynx(8) G.-w.teal(7) Marsh hawk(3) Spr.grouse(8)	G.bear(10) Mountain goat/Bighorn sheep(10) G.eagle(8) W-t.ptarmigan(9)	N/A	N/.A
Emergent zone/ shoreline	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Muskrat/Moose(12) Can.goose(8) Bald eagle/Osprey(8)	Muskrat/Moose(12) Can.goose(8) Bald eagle/Osprey(8)
Open water	N/A	N/A	N/A	N/A Can.goose(8)	N/A Can.goose(8)	N/A	N/A	Muskrat(12) Bald eagle/Osprey(8)	Muskrat(12) Bald eagle/Osprey(8)

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[1] The highest scoring carnivore, herbivore, waterbird, raptor and upland gamebird species in each stratum are listed for purposes of comparison. The key species selected for each stratum is underli

3.0 SNOWSHOE HARE

3.1 GENERAL

Snowshoe hares are widely distributed, occurring throughout the province except for the southeastern part of the grassland zone (Soper 1964; A.F.W.D. 1984). They are absent from higher elevation areas of the Mountain biome due to lack of habitat, but are relatively more abundant in the foothills (Preble 1908; Soper 1964, 1970; Salt and Clarke 1979; Mill and Andersen 1980; Holroyd and VanTighem 1983). The species was previously important to the fur-trapping industry but due to market changes significant numbers are no longer taken (A.F.W.D. 1984).

3.2 FOOD

Snowshoe hares are largely herbivorous, although some carrion may be eaten when available (Soper 1964). The diet of this species within the province in general consists of grasses and forbs and the foliage, twigs and bark of various trees and shrubs (Soper 1964). Fall and winter diets are composed almost entirely of hardwood and coniferous browse, with a variety of green plant material being used in spring and summer (review by Green 1979).

Food habits data from the Mountain and Foothill biomes are lacking except for scattered incidental observations. Foods utilized include an array of grasses and forbs, and the leaves, twigs and/or bark of aspen, willow, birch, rhododendron, Menziesia and other shrubs, and of lodgepole pine, spruce and fir (Preble 1908; Millar 1953; Fitzmartyn and Holroyd 1978; Salt and Clarke 1979). However, as snowshoe hares are opportunistic feeders (Wolff 1978; Pease et al. 1979) the range of food plants used in these biomes is certainly much broader. Preferred or major food species elsewhere (reviewed by Wolff 1978; Green 1979; U.S.F.W.S. 1984a), and that occur in the Mountain and Foothill biomes, include white spruce, black spruce, larch, Douglas fir, aspen and balsam poplar, paper and dwarf birch, several willows (including the very common Salix bebbiana), green and river alder, gooseberry, raspberry, prickly rose, high-bush cranberry, beaked hazelnut, dogwood, Labrador tea, bog cranberry, bog bilberry, white spiraea (meadowsweet), balsam-root, arnica, fireweed, horsetails and june grass. It is noteworthy, however, that some of these (black spruce, Labrador tea) have been found to be unpalatable and little used in studies in northcentral Alberta (Keith et al. 1984), as have low-bush cranberry, twining and bracted honeysuckle, and snowberry (Pease et al. 1979; Keith et al. 1984).

During periods of abundance snowshoe hares may utilize up to 100% of the browse available (Wolff 1980), but normally food selection is determined by a combination of factors, including abundance and distribution of individual plant species, and their nutrient content and palatability (Wolff 1978). Winter feeding experiments in the Rochester area indicated a mean individual daily requirement of approximately 300 g of woody browse having a diameter of 4 mm or less; hares could not maintain weight and died if kept on a diet of larger twigs (Pease et al. 1979). In the same area, Keith et al. (1984) defined hare food as browse within 60 cm of ground or snow level and having twig diameters of 4 mm or less, and measured early winter forage biomasses as ranging between 63 and 540 kg/ha. It is noteworthy that snow accumulation can act both to decrease food availablility, by burying unused food supplies, or to increase it by providing better access to above snow portions of browse plants.

3.3 COVER AND TERRAIN

Snowshoe hares utilize forest and shrub growth for food, and for hiding, reproductive and thermal cover. In the mountains they extend into the subalpine and even the true alpine in the vicinity of suitable shrub cover, but make greatest use of the forested lower slopes and valleys (Soper 1970, 1973). Holroyd and VanTighem (1983) found that of the 26 cover types receiving high use by hares, 19 were closed forests. Cover types used include a variety of conifer forests (composed of lodgepole pine, white spruce, black spruce, Douglas fir), mixed coniferous/ deciduous woods, aspen forest, spruce bogs, and alder, willow, buffalo-berry and silverberry thickets (Soper 1964, 1970, 1973; Nielsen 1973; Fitzmartyn and Holroyd 1978; Salt and Clarke 1979; Holroyd and VanTighem 1983). In the mountains, aspen, balsam poplar, subalpine larch and Engelmann spruce/subalpine fir forests appear to receive relatively low levels of utilization (Holroyd and VanTighem 1983).

The availability of a dense shrub layer is a key habitat feature for this species. This relationship has been well-documented elsewhere (Keith 1966; Van Camp and Telfer 1975; Wolff 1980) and appears to hold also in the Mountain and Foothill biomes, where thickets developed in bogs and under forest cover, at the edges of alpine and subalpine meadows, along the borders of streams and lakes, along avalanche tracks and in windfall areas provide major blocks of habitat (Soper 1964, 1970, 1973; Nielsen 1973; Fitzmartyn and Holroyd 1978; Salt and Clarke 1979; Holroyd and VanTighem 1983). Similarly, clearcut areas in the foothills support high populations of snowshoe hares once suitable conifer and shrub cover have developed (Stelfox et al. 1973; Stelfox 1981). Holroyd and VanTighem (1983) suggested that habitat could be manipulated to favor hares by controlled burning of alluvial forests to maintain a young, shrubby forest cover. Conversely, heavy browsing and removal of the shrub layer by ungulates can severely limit habitat suitability for this species (Van Camp and Telfer 1975).

Deadfall is also used for cover and bed sites, and may be an important determinant of winter distribution of hares (Fitzmartyn and Holroyd 1978).

3.4 SPACE

Snowshoe hares are relatively sedentary, occupying well-defined but overlapping home ranges that vary from 7 to 14 ha (Wolff 1980). Data are not available from the Mountain and Foothill biomes in Alberta, but in the Rockies to the south adult home range size was shown to average 8 ha in spruce-fir forest, the preferred habitat (Dolbeer and Clark 1975).

Snowshoe hare populations undergo cyclic fluctuations, reaching peak densities every 8-11 years (Keith 1963). Although not as well-documented as elsewhere, population fluctuations do occur in the Foothill and Mountain areas (Soper 1964).

These cycles are important determinants of use of space and habitat. It has been shown elsewhere that during periods of population expansion successively less favorable areas are occupied, whereas during low points in the cycle the population retreats into pockets of the most favorable habitat (Keith 1966; Keith and Windberg 1978; Wolff 1980), resulting in a mosaic of hare densities related to habitat quality. This probably explains observations in western Alberta of local abundance of hares in some areas but scarcity or virtual absence in others (Preble 1908; Clarke 1942; Banfield 1958).

During a population high in the early part of the century, peak hare densities in the Mountain parks were estimated at 1000 or more per mi^2, an equivalent of 3.9/ha (Soper 1947; Banfield 1958), but they subsequently were scarce (Soper 1970). No data are available for the foothills, although in the boreal mixedwood region to the east hare populations have fluctuated between lows of 1.3 to 2.6/ha and highs of 5.9 to 11.8/ha (Windberg and Keith 1978), and up to 18.2/ha in regenerating burned habitat (Keith et al. 1984).

3.5 SIZE AND INTERSPERSION OF HABITAT UNITS

Interspersion or patchiness appears to be an important component of snowshoe hare habitat, although this factor has not been quantified in western Alberta. Studies in Alaska have shown that patchy habitat (dense black spruce and willow thickets interspersed with open areas) permitted snowshoe hares to feed on herbaceous material and low shrubs in openings in summer, then shift to a browse diet obtained from dense thickets in winter (Wolff 1980). Salt and Clarke (1979) noted that in the Kananaskis area in winter hares kept to dense shrub cover during the day but wandered in the open at night. In addition, dense thickets are important refugia during population crashes (Keith 1966; Wolff 1980).

In mature forests, snowshoe hares may depend on an interspersion of openings (Dodds 1960). Several natural physical processes (wind and water action, fire, avalanches) and human activities (logging) serve to create or maintain openings used as hare habitat in the mountains and foothills, but data on optimum size and interspersion are lacking. Studies on effects of logging elsewhere have suggested that for maximum utility to hares, cut blocks should be small or shaped so that canopy cover is available within 200-400 m of all parts of the opening (Conroy et al. 1979).

3.6 HABITAT MODELS

Green (1979), Green et al. (1984) and LGL Ltd. (1986a, 1986b) review the literature on snowshoe hare food habits and habitat utilization. LGL Ltd. (1986a, 1986b) also provide habitat suitability models for study sites in northeastern and southwestern Alberta, respectively. An additional review of habitat requirements and formulation of a habitat model, based largely on data from Alaska, are in preparation (U.S.F.W.S. 1984a).

4.0 RED SQUIRREL

4.1 GENERAL

Red squirrels are widely distributed in Alberta, occurring primarily in association with mature conifer woodlands throughout the Boreal Forest, Mountain and Foothill biomes. They also extend well into the Aspen Parkland zone, although their distribution within this biome is sporadic (Soper 1964; Todd 1978; A.F.W.D. 1984). As they are highly visible, red squirrels have high recreational value; they also are a staple of the fur industry (A.F.W.D. 1984).

4.2 FOOD

Within their Alberta range red squirrels subsist primarily on conifer seeds and buds, but also make opportunistic use of deciduous buds, mushrooms, hazelnuts, rosehips, bearberries, the bark and resinous excretions of pine galls, and occasionally animal foods such as insects and bird's eggs and fledglings (Soper 1964; Kemp and Keith 1970; Rusch and Reeder 1978; Todd 1978; Salt and Roth 1979). Freshly cut white spruce and black spruce cones are preferred over old cones and over jack pine cones, although actual use depends on availability (Rusch and Reeder 1978). Captive feeding experiments have shown that an average 176 new black spruce cones or 123 new white spruce cones are required per squirrel per day (Rusch and Reeder 1978).

Beginning in mid- to late summer red squirrels make extensive caches of cones, and to a lesser extent of mushrooms and hazelnuts, for subsequent winter use (Smith 1968; Kemp and Keith 1970; Zirul 1970; Rusch and Reeder 1978; Todd 1978). Under Alberta conditions these food stores are relied on for at least half of the year (Rusch and Reeder 1978). Subnivean and subterranean tunnels to food stores provide accesss even under severe winter conditions (Zirul 1970).

4.3 COVER AND TERRAIN

Mature white spruce or mixed white and black spruce stands are considered to provide optimum habitat for red squirrels, although a variety of other treed habitats are utilized (Wood 1967; Davis 1969; Kemp and Keith 1970; Rusch and Reeder 1978; Todd 1978). Both population densities and annual survival are highest in spruce forests, which are inhabited by a high proportion of adults, and are lowest in aspen forests, which are inhabited primarily by juveniles (Rusch and Reeder 1978). A capability classification developed through extensive sampling of representative forest types in the province (Todd 1978) succinctly illustrates the continuum of habitats occupied and their relative value to this species:

Class 1: Mature white spruce or mixed white and black spruce. Tightly interspersed black spruce stands or small wooded muskegs may comprise up to 33% of the area. Probable resident squirrel density, assuming mature stands and moderate or greater tree densities, 178+ adults/100 ha

Class 2: White or mixed spruce dominant, with jack pine or lodgepole pine comprising 1/4 to 1/2 the basal area. Probable density 115-175 adults/100 ha.

Class 3: Mature stands dominated by jack pine or lodgepole pine, or deciduous stands with white spruce comprising 1/4 to 1/2 the basal area. Probable density 85-112 adults/100 ha.

Class 4: Deciduous-dominated mixed stands with pine comprising 1/4 to 1/2 the basal area; deciduous stands with heavy hazelnut understory; black spruce bog. Probable density 48-82 adults/100 ha.

Class 5: Other deciduous stands. Probable density 12-45 adults/100 ha.

Class 6: Open muskeg; muskeg woods with tamarack. Probable density <12 adults/ 100 ha.

Class 7: Cultivated fields; naked talus slopes or rock outcrops. Probable density nil.

4.4 SPECIAL HABITAT FEATURES

Subterranean dens, hollow trees and leaf nests are used by both sexes for resting, and for the birth and raising of young (Todd 1978; Fancy 1980). Large accumulations of shredded cones (middens), which may be used continuously for several years by a succession of different squirrels, provide shelter, an area for cone storage, and a focal point for squirrel activity (Green 1979).

4.5 SPACE

Use of space by red squirrels varies with the species, density, maturity and quality of cone-bearing trees available (Rusch and Reeder 1978; Todd 1978). In coniferous habitats individuals establish exclusive territories from which all other squirrels (with the temporary exceptions of juvenile young and breeding males in adult female territories) are actively excluded (Kemp and Keith 1970; Rusch and Reeder 1978). Territories function in providing both a source of food for storage and exclusive use of a centralized food cache; their size in various habitats approximates the area required to produce a sufficient food supply even in a poor crop year (Rusch and Reeder 1978). Thus, in the Rochester area of central Alberta, territories were smallest in preferred white spruce habitat (mean 0.24 ha), followed by mixed spruce (0.35 ha) and jack pine (0.66 ha), while territorial behaviour was either nonexistent or poorly developed in deciduous habitat, which offers a very limited and thinly dispersed winter food supply (Kemp and Keith 1970; Rusch and Reeder 1978).

Red squirrels are relatively sedentary throughout the year, with the exception of spring and fall dispersal movements (Rusch and Reeder 1978). Although nonterritorial (primarily juvenile) animals may be forced into suboptimal wintering areas, the subsequent spring dispersal provides a mechanism for redistribution into better quality habitat left unoccupied by overwinter mortality or movement of territorial occupants (Kemp and Keith 1970; Zirul 1970; Rusch and Reeder 1978).

4.6 SIZE AND INTERSPERSION OF HABITAT UNITS

Minimum habitat block size required to sustain a viable population of red squirrels has not, to our knowledge, been documented directly, but can be inferred from the population density and territory size data provided above. Additional considerations are tree density, stand age and cover type interspersion. Thus, although trees in open or scattered stands may produce more cones than trees in dense stands, habitat value is decreased if cone-bearing trees are very widely spaced (Todd 1978). Disturbances such as logging and forest fires reduce stand age and at least temporarily reduce habitat value for red squirrels (Todd 1978). Also, although stands of white or mixed spruce are considered to provide optimal habitat, an interspersion of suboptimal types (e.g., black spruce, jack pine or aspen stands) provides food sources during years of white spruce cone shortage, and buffer habitat for juvenile dispersal (Wood 1967; Smith 1968; Kemp and Keith 1970; Rusch and Reeder 1978).

4.7 HABITAT MODELS

Todd (1978), Green (1979) and LGL Ltd. (1986a) review habitat requirements of this species. Todd (1978) also outlines criteria for assessing and mapping land capability for red squirrels in Alberta, based on a minimum map unit size of 2.5 km^2, while LGL Ltd. (1986a) provides a habitat suitability model for northeastern Alberta.

5.0 BEAVER

5.1 GENERAL

Beavers occur throughout the province, with the exception of most of the grassland zone (Soper 1964; A.F.W.D. 1984). Prime beaver range coincides approximately with the Aspen Parkland biome (A.F.W.D. 1984), but they are locally abundant in the Boreal Forest and Foothill regions under suitable conditions. Their altitudinal range in the mountains extends to the upper subalpine (Holroyd and VanTighem 1983). Major habitat requirements are waterbodies suitable for year-round occupation, and an adjacent supply of food and building materials in the form of deciduous woods or shrublands (Slough and Sadleir 1977; Todd 1978).

Beavers are of major importance to the fur-trapping industry and for recreational viewing (A.F.W.D. 1984). Their ability to manipulate water levels provides habitat for a number of other species, but they may become problem animals by flooding roads and other developments (A.F.W.D. n.d.a, 1984).

5.2 FOOD

Beavers forage primarily on the bark, twigs, leaves and to some extent green wood of deciduous trees and shrubs, and to a lesser degree on herbaceous terrestrial vegetation; aquatic macrophytes such as yellow pond lily also are utilized when available (reviews by Todd 1978, Searing 1979a and Allen 1983). Species used in Alberta include willows, aspen, balsam poplar, paper birch, dwarf birch, rose, dogwood, silverberry, beaked hazelnut, saskatoon and alder (Novakowski 1967; Soper 1970; Sverre 1972; Nielsen 1973; Salt and Clarke 1979; Skinner 1984). Willow, aspen and possibly balsam poplar appear to be the preferred foods on a province-wide basis (Novakowski 1967; Sverre 1972; Skinner 1984).

In most areas of Alberta woody vegetation is harvested and stored for winter use in the form of aquatic food caches (Novakowski 1967; Todd 1978; Skinner 1984). However, in the Porcupine Hills, and possibly elsewhere subject to mild winter conditions, beavers forage onshore during winter and do not construct food stores (Sverre 1972).

5.3 COVER AND TERRAIN

Beavers occupy a variety of aquatic habitats, ranging from ponds and small streams to the larger lakes and rivers (Soper 1964, Sverre 1972; Todd 1978; Holroyd and VanTighem 1983). Minimum water depths of 0.9-1.5 m are required under Alberta climatic conditions (Todd 1978), mainly to enable travel beneath ice. Marginal habitat may be improved by blocking outflow areas or slow-flowing streams with dams constructed of sticks and mud (Soper 1970; Sverre 1972; Todd 1978; A.F.W.D. 1984; Skinner 1984). Streams with gradients of up to 13% are occupied, although dams tend to be constructed on stream sections with somewhat lower gradients (e.g., 5 to 7%: Sverre 1972). Gentle to moderate slopes (as opposed to steep slopes) adjacent to waterbodies facilitate foraging and limit erosion (Sverre 1972).

Mud and stick lodges, with entrances under water, are constructed by beavers and provide thermal, escape, resting and reproductive cover (Novakowski 1967; Sverre 1972; Todd 1978). Bank dens also are used in some Foothill and Mountain areas (Millar 1953; Soper 1970, 1973; Nielsen 1973). Clay soils are preferred for construction purposes (Sverre 1972).

In addition to aquatic sites providing adequate water depths and stability, beavers require a nearby source of food and building materials for dams and lodges. Colonies are most commonly associated with deciduous tree/shrub subclimax or edaphic climax plant communities (Slough and Sadleir 1977). Aquatic sites occupied in the mountains and foothills may be surrounded by forest, shrub or herbaceous cover, but vegetation near the water's edge is usually willow, poplar or other deciduous growth (Sverre 1972; Holroyd and VanTighem 1983). Similarly, in the boreal forest, lodges usually are located in habitats dominated or codominated by willow, aspen, balsam poplar, birch or other deciduous species (Novakowski 1967; Searing 1979a, 1979b; Skinner 1984). Conifers are little used for either food or construction materials (Novakowski 1967; Soper 1970; Sverre 1972; Skinner 1984) and the occasional siting of lodges in coniferous habitats probably is related to the presence of some deciduous trees (Searing 1979a, 1979b).

Willow provides the most stable habitat, forming an edaphic climax in many riparian situations and regenerating after browsing (Sverre 1972; Slough and Sadleir 1977). Conversely, aspen occurs in fire subclimax stands that generally produce only one crop, and that are replaced by willows (Sverre 1972) or conifers (Slough and Sadleir 1977) when removed by beavers. Nevertheless aspen stands provide important habitat where they occur (Novakowski 1967; Sverre 1972; Holroyd and VanTighem 1983; Skinner 1984), and perpetuation of aspen habitat has been proposed by Slough and Sadleir (1977) as a beaver management tool.

Beavers are tolerant of human activities, but transportation corridors and land clearing adjacent to waterways may adversely affect habitat suitability (Slough and Sadleir 1977).

5.4 SPACE

Beavers occur in colonies consisting of a monogamous pair of adults, subadults and young of the year, with an average colony size of five (reviews by Sverre 1972 and Allen 1983). Colonies occupy distinct and nonoverlapping territories, and use of space is determined by social as well as by habitat factors.

Except for long-distance dispersal movements undertaken by subadults, beavers appear to remain within relatively confined home ranges, foraging a maximum 245 m (but usually 30 m or less) inland, and up to 800 m along shore from the lodge or cache (Novakowski 1967; Soper 1970; Sverre 1972; Skinner 1984; also reviews by Todd 1978, Searing 1979a and Allen 1983). Based on plant biomass data, Sverre (1972) calculated that 0.08 ha of forest/shrub habitat could supply the annual food requirements of a colony in the foothills. Novakowski (1967) reported colony feeding areas ranging between 0.12 and 0.57 ha in the boreal forest.

Population densities of 0.16 colonies/km of stream have been documented in the southern foothills (Sverre 1972), but density data apparently are not available for other areas of the Mountain and Foothill biomes. Selected studies in the boreal forest have reported between 0.32 and 1.13 colonies per km of stream (Novakowski 1967; Searing 1978a, 1978b), and up to 0.94 colonies per km^2 of total habitat (Skinner 1984). It is noteworthy here that Allen's (1983) habitat model assumes that a minimum of 0.8 km of stream channel or 1.3 km^2 of lake/marshland habitat needs to be available to be suitable for occupation by beavers.

5.5 SIZE AND INTERSPERSION OF HABITAT UNITS

The best beaver habitat is characterized by an interspersion of stable waterbodies and deciduous tree and shrub growth (Todd 1978). Optimum conditions are provided where wetlands cover 10-50% of the land area, and where interconnecting streams or low marshy areas permit increased access to onshore food supplies (Slough and Sadleir 1977; Todd 1978). Todd's (1978) capability classification succinctly summarizes size, interspersion and other physical characteristics of optimal beaver habitat in Alberta:

1. Streams: average drainage density about 1.8 km of stream/km^2 of land surface area or more; about 50% of stream length is permanent with the following description: low gradient (< or = 3%), meandering streams generally 1.5-7.5 m wide and 0.9-1.5 m or more deep; discharge ranging from 6 to 2832 l/s. Valley width >45 m with a variably broad, mesic floodplain covered with willow and alder. Aspen and possibly balsam poplar available within 90 m of stream edge on gently to moderately sloping (<25%) valley slopes. Ideal valley alignment is basically east-west. Tributary intermittent creeks provide additional colony sites. The soil type on the stream banks must be sufficiently heavy-textured to support dam construction.

2. Lakes/potholes: lakes with numerous islands and highly irregular shorelines (e.g., 3.2 km of shoreline/km^2 of surface area) may provide excellent beaver habitat provided that water depths are adequate, mud substrates are available for lodge construction, and suitable deciduous tree or shrub food sources are available. High density complexes of small, irregular lakes and potholes may also provide ideal beaver habitat.

5.6 HABITAT MODELS

Sverre (1972), Todd (1978), Searing (1979a), Green et al. (1984; 1986), Nietfeld et al. (1984) and LGL Ltd. (1986a, 1986b) provide reviews of beaver habitat requirements with specific reference to Alberta. Other reviews include those by Slough and Sadleir (1977), Allen (1983) and U.S.F.W.S. (1984b).

Todd (1978) outlines criteria for assessing and mapping land capability for beaver production in Alberta, based on a minimum map unit size of 2.5 km^2. IEC Beak (1984a) provide a quantitative model for assessing beaver habitat suitability in each of 278 habitat subregions (homogeneous land units) in Alberta, as discerned from 1:500 000 scale Landsat imagery. Habitat suitability models have also been developed with specific reference to northeastern Alberta (LGL Ltd. 1986a), southwestern Alberta (LGL Ltd. 1986b) and agricultural wetlands in central and northern Alberta (Green et al. 1986). Models developed elsewhere, but applicable to provincial conditions, include those of Slough and Sadleir (1977), Allen (1983) and Howard and Larson (1985).

6.0 MUSKRAT

6.1 GENERAL

Muskrats are found throughout the province (Soper 1964; A.F.W.D. 1984). They are rare in the mountains (where suitable aquatic habitat is very limited), are relatively more common and well-distributed in the foothills, and are most abundant and widely distributed in the Aspen Parkland and Boreal Forest biomes (Soper 1947, 1964, 1970; Wallis and Wershler 1972; Salt and Clarke 1979; Mill and Andersen 1980; A.F.W.D. 1984). Although populations appear to have declined in recent years the species continues to be an economically important furbearer (A.F.W.D. 1984).

6.2 FOOD

Muskrats feed primarily on aquatic vegetation, but agricultural crops and animal matter are used in some situations (Errington 1961; Willner et al. 1975). Cattails and bulrushes are the most important forage species within the North American range (Willner et al. 1975; Allen and Hoffman 1984). Although a number of studies have identified a preference for cattails (review by Allen and Hoffman 1984), a strong preference for bulrush has been documented in central Alberta (Welch 1980). and in the Peace-Athabasca Delta region sedge is the major forage used (Westworth 1974). Submergents are locally and/or seasonally important food sources (Fuller 1951; Stevens 1955; Westworth 1974; Welch 1980). Forages reported to be used in Alberta aspen parkland include great bulrush, common cattail, pondweed, water milfoil, spike rush and arrowhead (Welch 1980), while in northern Alberta Westworth (1974) reported use of sweetflag, giant bur-reed, sedge, common great bulrush, water milfoil, clasping-leaf and other pondweeds, and duckweed.

6.3 COVER AND TERRAIN

Primary habitat requirements are aquatic and semi-aquatic plant growth sufficient for food and cover, and water depths adequate for year-round foraging. These requirements are met by a variety of wetland types including weedy lakes, ponds (including beaver ponds), sloughs, marshlands and low gradient streams (Soper 1964; A.F.W.D. 1984). Suitable vegetation includes emergent stands of bulrush, cattail, giant bur-reed, horsetails, sedges and grasses (e.g., reed grass, tufted hairgrass), and submergent beds of water milfoil, pondweed and other species; seasonally flooded shrublands composed of willows, dwarf birch and shrubby cinquefoil also are used (Soper 1970; Ambrock and Allison 1973; Westworth 1974; Poll 1980; Welch 1980; Holroyd and VanTighem 1983).

Where dense emergent vegetation is available muskrats construct houses for thermal and hiding cover, and for raising litters; dens constructed in stable banks, with the entrances under water, also are widely used (Law 1950; Fuller 1951; Stevens 1955; Schmitke 1959; Soper 1970, 1973; Ambrock and Allison 1973; Westworth 1974). Banks suitable for denning feature fine-textured soils and a relatively steep drop-off from shore, permitting access under ice (Stevens 1955; Todd 1978). Riparian vegetation contributes to bank stability and traps an insulating layer of snow, which may limit ice development over burrow entrances (reviews by Todd 1978 and Searing 1979a).

Optimum water depths (i.e., permitting both development of emergents and travel beneath ice in winter) range between 0.6 and 2.1 m under Alberta climatic conditions (Schmitke 1959; Surrendi and Jorgenson 1971; Ambrock and Allison 1973; Todd 1978), but depth requirements are flexible during the open water season. Although low, excessive, or rapidly fluctuating water levels can all result in increased muskrat mortality, the best habitats are dependent on periodic flooding and drawdowns to retard plant succession and permit regeneration of submergents (Fuller and La Roi 1971; Westworth 1974; Todd 1978; Poll 1980; Holroyd and VanTighem 1983). Semi-stable water regimes with severe drawdowns every 3-5 (Poll 1980) or 5-10 years (Todd 1978) are considered optimal.

6.4 SPACE

Dispersion of muskrats within blocks of suitable habitat is dependent on both habitat quality (distribution and abundance of food, cover and water) and social factors. Except for seasonal dispersal movements, they generally remain within home ranges of 200 m or less in diameter, part of which area may be defended against other muskrats (Fuller 1951; Stevens 1955; Schmitke 1959; Westworth 1974; review by Searing 1979a). Excellent quality habitat units in Alberta would be expected to sustain in excess of 40 active houses/km^2 (Todd 1978).

6.5 SIZE AND INTERSPERSION OF HABITAT UNITS

Good muskrat habitat features stable water levels (but with periodic drawdowns), extensive development and interspersion of shoreline cover and emergent and submergent growth, and good bank development providing access to deep water during winter. Based on these characteristics, Todd (1978) outlined the following size and interspersion characteristics of areas with very high to moderately high capability for muskrat production in Alberta:

Class 1: Units comprised almost entirely of irregular lakes and/or marshes with adequate water depths, and extensive offshore emergents well interspersed with submergents throughout. Percent of area covered by emergent stands may vary from 10 to 60+%.

Class 2: Units where numerous small (0.4 to 16 ha), irregular sloughs cover more than 50% of the area, with abundant emergents throughout and well-developed emergent stands offshore, or with shoreline development suitable for bank dens.

Class 3: Shallow lakes less than 10 km^2 in size, with regular shorelines suitable for burrowing and abundant submergents throughout, or moderately high density sloughs and potholes as in Class 2 above.

6.6 HABITAT MODELS

Todd (1978), Searing (1979a), Green et al. (1984, 1986) and LGL Ltd. (1986a) summarize habitat requirements of this species. Allen and Hoffman (1984) outline a generalized habitat suitability index model, based on a review of the world literature, while Green et al. (1986) and LGL Ltd. (1986a) provide habitat suitability models specific to Alberta. Todd (1978) also details a system for rating present capability of land units for muskrat production in the province.

7.0 CARIBOU

7.1 GENERAL

Caribou have a limited distribution in Alberta, occupying a discontinuous range in the mountains and foothills and over the northern half of the province (A.F.W.D. 1984). In the mountains they occur from the northern part of Banff National Park through Jasper N.P. to the British Columbia border, extending out into the foothills only between the Athabasca and Wapiti Rivers (Bloomfield and Sword 1981). The area occupied was formerly much broader, but numbers have declined as a result of habitat loss, disturbance and over-hunting (Soper 1964, 1970; Bloomfield 1980; A.F.W.D. 1984). Sport hunting of this species was closed in 1980, the only current uses being recreational viewing and native subsistence hunting (A.F.W.D. 1984).

7.2 FOOD

Caribou food habits vary seasonally, the major feature being a switch from arboreal lichens in winter to new growth of vascular plants in spring (Stelfox et al. 1978). The switch to new growth probably reflects selection for increased protein levels, as has been documented in interior British Columbia (Bergerud et al. 1984).

Year-long diets include a variety of graminoids, forbs, deciduous shrubs and dwarf shrubs, and both terrestrial and arboreal lichens (Stelfox and Taber 1969; Soper 1970; Stelfox et al. 1978; Bloomfield et al. 1981; Holroyd and VanTighem 1983). Major food plants identified during a detailed study in Jasper N.P. are listed in Table 16.

7.3 COVER AND TERRAIN

In the mountains, caribou are associated mainly with the alpine and subalpine zones (Stelfox and Taber 1969; Soper 1970; Stelfox et al. 1978; Holroyd and VanTighem 1983). On a broad scale, their distribution is correlated with the distribution of mature conifer forests and alpine tundra ranges with broad valleys, traversable passes, and scattered summer snowfields (Stelfox et al. 1978). Conversely, in the outer Foothill and Boreal Forest regions woodland habitat may be used year-round (Thompson et al. 1980; Fuller and Keith 1981).

Important habitats are alpine tundra, lower elevation meadows and shrublands (including delta/shoreline alluvial communities) and mature conifer forests (Stelfox and Jasper National Park Warden Service 1974; Stelfox and Bindernagel 1978; Stelfox et al. 1978; Bloomfield et al. 1981; Fuller and Keith 1981; Holroyd and VanTighem 1983). Black spruce muskeg is a major caribou habitat in the northeastern part of the province (Fuller and Keith 1981) and may be important in the Foothill biome. Early seral habitats (avalanche paths, burns, man-made grasslands) are little used or avoided (Stelfox et al. 1978), as are deciduous and mixed woods (Fuller and Keith 1981).

Habitat use varies seasonally with floral phenology and forage availability. During the spring-summer period, areas of new plant growth are actively sought, mainly in open (non-forested or muskeg) habitat types (Stelfox et al. 1978; Fuller and Keith 1981). Conversely, extensive mature or over-mature forests are important for over-winter survival, although windswept ridges and meadows adjacent to forest cover also are used at this time (Stelfox et al. 1978; Bloomfield et al. 1981). In the mountains, Engelmann spruce - subalpine fir forests are preferred over the younger lodgepole pine forests (Stelfox et al. 1978; Holroyd and VanTighem 1983; Kaye and Roulet n.d.), but in some areas lodgepole pine, lodgepole pine-white spruce (Bloomfield et al. 1981) or jack pine-spruce

Table 16. Food species used by caribou in Alberta.

Species	Reference, Area and Diet Composition[1] Stelfox et al. 1978 (Jasper N.P.)
Trees and Shrubs	
Abies lasiocarpa	0.71%
Arctostaphylos uva-ursi	0.07%
Betula glandulosa/Betula spp.	2.55%
Cassiope mertensiana	1.05%
C. tetragona	1.43%
Dryas integrifolia	3.80%
D. octopetala	2.20%
Empetrum nigrum	0.37%
Ledum groenlandicum	0.44%
Menziesia glabella	–
Phyllodoce empetriformis	0.67%
P. glanduliflora	0.94%
Potentilla nivea	1.90%
Salix arctica	0.33%
S. nivalis	0.44%
Senecio resedifolius/Senecio spp.	2.09%
Solidago multiradiata	0.32%
Vaccinium vitis-idaea	1.18%
Graminoids	
Bromus marginatus	0.06%
Carex albo-nigra	1.25%
C. concinna	1.90%
C. scirpoidea	1.91%
C. spectabilis	1.30%
Festuca brachyphylla	0.18%
Phleum alpinum	0.18%
Trisetum spicatum	0.13%
Forbs	
Caltha leptosepala	1.00%
Linnaea borealis	1.90%
Pedicularis arctica	3.80%
Trollius albiflorus	0.74%
Valeriana sitchensis	1.90%
Zygadenus elegans	0.65%
Horsetails, Club-mosses and Mosses	
Equisetum scirpoides	4.27%
Dicranum scoparium	0.34%
Lucobryum glaucum	0.65%
Pleurozium schreberi	3.80%
Polytrichum piliferum	2.85%
Ptilium crista-castrensis	0.65%
Rhacomitrium canescens	0.65%
R. lanuginosum	5.70%
Lichens	
Alectoria glabra	0.65%
Cetraria nivalis	1.10%
C. pinastri	0.65%
Cladina arbuscula	1.90%
Cladonia cornuta	0.65%
C. deformis	0.65%
Peltigera apthosa	1.98%
Stereocaulon paschae	0.65%

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[1] Percent year-long diets estimated from range transects as % canopy cover x %utilization.

(Fuller and Keith 1981) are the major forest habitats used. Selection of forest cover is strongly related to forage availability, particularly of arboreal lichens (Bloomfield et al. 1981; Fuller and Keith 1981). Forests are also used for escape cover (Stelfox and Taber 1969), and possibly for thermal cover. Closed forests are important during winter, but forests used during summer feature mainly open canopies and shrubby understories (Holroyd and VanTighem 1983).

Caribou make use of all exposures on a year-long basis (Stelfox et al. 1978), depending on cover type and slope inclination (Stelfox et al. 1978; Bloomfield 1979a). In Jasper, caribou make greatest use of southwest, south and northwest exposures year-long, of northwest and northeast exposures during winter, of north slopes during spring, and of south, southeast and north exposures during summer (Stelfox et al. 1978), preferring rolling till plains and inclined till slopes (Holroyd and VanTighem 1983). East of the park, caribou appear to favor flat to moderate slopes of south, east and west aspects during winter (Bloomfield et al. 1981).

South-facing alpine slopes may be critical calving areas, providing bare ground for foraging, a dark background against which females are cryptic, and proximity to rugged escape terrain (Bergerud et al. 1984). Bergerud et al. (1984) demonstrated that in the Spatsizi area of British Columbia calving females sought such high elevation areas in spring even though doing so meant foregoing foraging in the most nutritious plant associations.

Caribou can utilize deep snow winter ranges, their large hoof areas and relatively low foot loads (Telfer and Kelsall 1971) easing travel through snow, and their large hooves permitting efficient pawing for herbaceous vegetation beneath the snow surface (Stelfox et al. 1978; Bloomfield et al. 1981). Stelfox et al. (1978) found caribou in areas with snow depths of up to 130 cm. Caribou also make use of areas with reduced snow depth, such as windswept ridges and other upland areas (Stelfox et al. 1978; Fuller and Keith 1981), and can switch to a diet of arboreal lichens under forest cover when conditions are unfavorable for cratering (Bloomfield et al. 1981; Holroyd and VanTighem 1983).

7.4 SPECIAL HABITAT FEATURES

Alpine snowfields or snow patches are an important feature of summer habitat in the mountains, being used for thermoregulation and escape from insects (Stelfox et al. 1978; Holroyd and VanTighem 1983; Kaye and Roulet n.d.).

Caribou utilize natural mineral licks (Cowan and Brink 1949; Holroyd and VanTighem 1983) and also lick salt from roads (Bloomfield et al. 1981; Holroyd and VanTighem 1983). Jones and Hanson (1985) concluded that caribou seek out alkaline materials rich in magnesium and calcium, but the importance of licks to this species is not well understood.

7.5 SPACE

In the Mountain and Foothill biomes, caribou undertake generalized shifts between low elevation (mainly winter use areas) and high elevation summer use areas (Clark 1942; Soper 1964, 1970; Bloomfield et al. 1981; Kaye and Roulet n.d.). Movements to distinct seasonal ranges have also been reported for caribou in the Boreal Forest, but movement patterns appear to vary greatly among individuals (Fuller and Keith 1981) and populations (Darby and Pruitt 1984). Caribou are traditional in their area use patterns, using established, learned travel routes and calving, rutting and feeding grounds (Bloomfield 1980; Fuller and Keith 1981; Holroyd and VanTighem 1983; Kaye and Roulet n.d.). They avoid areas subject to human or mechanical disturbance (Soper 1970; Bloomfield 1980), and apparently can be displaced from feeding grounds by elk and horses (Stelfox and Bindernagel 1978; Kaye and Roulet n.d.).

Annual home range sizes are poorly documented in western Alberta, but have been estimated at between 630 and 1205 km^2 (Bloomfield et al. 1981). Highest densities occur on breeding grounds and late winter ranges; in the Berland area late winter densities are 1/27 km^2 (J. Edmonds, pers. comm. cited by Nietfeld et al. 1984). These figures compare well with data from the northeastern part of the province, where studies of radio-collared animals documented late winter densities of 1 caribou/24 km^2, and mean annual home range sizes from 539 km^2 for females to 1196 km^2 for males (Fuller and Keith 1981).

7.6 SIZE AND INTERSPERSION OF HABITAT UNITS

Caribou rely primarily on climax plant communities, ranging from extensive areas of alpine tundra to mature or over-mature conifer forests and muskeg, for their food and cover requirements. In general activities that reduce the extent of climax communities, such as logging and fire, are considered to reduce carrying capacity for caribou (Bloomfield 1980; Kaye and Roulet n.d.; A.F.W.D. 1984).

Although open (non-forested) areas are an extremely important feature of caribou habitat, proximity to forest cover may be a major determinant of their use. During spring and summer, caribou show some preference for alpine areas and subalpine meadows adjacent to mature forests (Bloomfield et al. 1981); forest edges and adjacent meadows are important winter habitats (Bloomfield et al. 1981; Holroyd and VanTighem 1983). Bloomfield (1980) has suggested that forest openings created artificially (e.g., through logging) should mimic the size of natural openings used by caribou. Conversely, stands of protective cover (as along migration routes) should be at least 400 m wide (Bloomfield 1979b).

Use of shrublands by caribou may be limited by anti-predator considerations. In interior British Columbia, caribou use only low shrublands where they have good visibility (low dwarf birch, and willow stands less than 19 cm tall); tall stands of willow are used only along the edges (Bergerud et al. 1984).

7.7 HABITAT MODELS

Habitat requirements and population dynamics of caribou inhabiting forested areas are reviewed in detail by Thompson et al. (1980). Nietfeld et al. (1984) also review key habitat requirements of woodland/mountain caribou as part of a model developed for habitat suitability rating in Alberta (IEC Beak 1984b). Van Daele and Johnson (1983) outline a method for estimating potential forages available to caribou in managed areas.

8.0 MULE DEER

8.1 GENERAL

Mule deer are widespread in Alberta, occurring in each of the Prairie, Aspen Parkland, Boreal Forest, Foothill and mountain biomes (Soper 1964; A.F.W.D. 1984). Numbers have declined throughout the southern and central parts of the province as a result of extensive land clearing, but the species remains relatively abundant in the foothills and in remnant habitat such as the major river valleys of the Prairie and Aspen Parkland zones (Kramer 1972; A.F.W.D. 1984). Although the northern and altitudinal distribution of mule deer is limited by severe winter conditions, a major northward expansion of the range well into the Boreal Forest biome has occurred during this century (Soper 1964; Kramer 1972).

Mule deer are harvested by both recreational and native subsistence hunters, and are a preferred species for recreational viewing (A.F.W.D. 1984).

8.2 FOOD

Browse provides the bulk of the annual diet, although succulent gramineous plants and forbs also are used when available (Cowan 1947; Sheppard 1960; Flook 1964). Cowan (1947) reported 79% browse, 15% grasslikes and 6% forbs in winter diets in Jasper. Browse species used in the province include choke cherry, saskatoon, dogwood, aspen, willows, black elder, dwarf birch, snowberry, green alder, rose, lodgepole pine, subalpine fir, bearberry, buffalo-berry, juniper and Douglas fir (Cowan 1947; Sheppard 1960; Flook 1964; Kramer 1972; Morgantini 1979; Berg 1983); use of the latter four is typical primarily of depleted winter ranges (Cowan 1947; Flook 1964).

8.3 COVER AND TERRAIN

Mule deer require browse-producing habitats for foraging, and thermal and escape cover in the form of dense shrub or tree growth (Flook 1964; Morgantini 1979; Thomas et al. 1979; Berg 1983). Broken or steep topography provides additional escape cover, although use of such topography may also be related to snow conditions and the availability of preferred vegetation types (Hudson et al. 1976; Morgantini 1979). Grasslands, shrublands and deciduous, mixed and coniferous woods on gently sloping to steep topography all are used to some extent in Alberta (Flook 1964; Soper 1964; Kramer 1972).

Deciduous growth provides cover primarily during the summer months, whereas conifer stands have year-round cover value (Thomas et al. 1979). South and west-facing slopes and conifer stands provide critical winter range in areas where accumulated snow depths of 30 cm or more restrict deer mobility (Telfer 1970, 1978a; Kramer 1973; Berg 1983).

In the Prairie and Aspen Parkland biomes much of the natural, semi-open vegetation cover favored by mule deer has been lost to agricultural development, and the species is now restricted largely to river valleys and to other areas of broken topography with remnant natural vegetation cover (Kramer 1972; A.F.W.D. 1984; Nietfeld et al. 1984). By contrast, mule deer are widely distributed in the Foothill and mountain biomes, utilizing a variety of largely seral vegetation types and ranging up to the subalpine zone and treeline (Sheppard 1960; Flook 1964; Kramer 1971; Morgantini 1979; Berg 1983). In the Boreal Forest biome, where the northern limits of the range are reached, valley complexes providing good browsing and favorable snow conditions are preferred (Nietfeld et al. 1984).

8.4 SPECIAL HABITAT FEATURES

Mule deer make use of natural mineral licks, primarily during June-July, but their nutritional importance is poorly understood (Cowan and Brink 1949; Sheppard 1960; Carbyn 1975; Jones and Hanson 1985).

8.5 SPACE

Use of space is largely dependent upon forage availability and snow depths. Some animals disperse over expanded ranges in summer, returning to traditional, spatially restricted winter ranges in valley bottoms and on slopes to avoid adverse snow conditions; others remain in the same area year-round (Flook 1964; Soper 1964; Kramer 1971; Telfer 1978a; Wallmo and Regelin 1981).

8.6 SIZE AND INTERSPERSION OF HABITAT UNITS

In general this species is associated with forest edge habitats and with seral forest communities, largely avoiding extensive monotypic and/or climax stands (Webb 1959; Flook 1964; Kramer 1972; Morgantini 1979). Fire and to some extent logging may be of long-term benefit to the extent that they increase habitat heterogeneity (Webb 1959; Flook 1964).

Studies on effects of logging in the Boreal Forest and lower Foothill region of west-central Alberta, where cutover areas gradually regenerate to shrub growth (Stelfox 1981; Tomm et al. 1981), provide some insight into optimum habitat management for this species. In this region deer strongly preferred cutblocks less than 40 acres (16.2 ha) in size, with a high edge per unit area ratio, and buffered from adjacent openings by residual forest widths greater than 402 m (Tomm et al. 1981). Scarified or scarified and burned blocks were preferred to untreated blocks, possibly because treated blocks produced more preferred herbaceous forage, and/or because treatment reduced logging debris and thus removed barriers to movement. Most deer use occurred near cutblock edges (within 100.5 m of cover), leading to the recommendation that forest openings be a maximum 201 m in width for optimum use by deer. Similar findings regarding the importance of adjacent cover have been reported from undisturbed areas; on the Ya Ha Tinda Ranch in west-central Alberta, 76% of observations of mule deer in open habitat (mountain slopes and grassland) occurred within 75 m of forests (Morgantini 1979).

Conifer stands provide optimum hiding and thermal cover, although deciduous stands also are useful when in leaf. Thomas et al. (1979) recommended that cover be at least 1.5 m tall with 75% or greater crown closure, and in stands of 0.8-2 ha (minimum width 91.5 m) for thermal cover and 2.6-5 ha (minimum width 183 m) for hiding cover.

8.7 HABITAT MODELS

General reviews of habitat requirements, focusing on Alberta but incorporating data from elsewhere in western North America, have been prepared by Kramer (1972), Green et al. (1984), Nietfeld et al. (1984) and LGL Ltd. (1986b). Wallis and Wershler (1979) and Norecol (1984) review habitat requirements and food habits with specific reference to reclamation of mule deer habitat in western Canada. IEC Beak (1984c) provides a biophysical model for use in rating habitat suitability of land units covering all of Alberta; a similar model developed specifically for southwestern Alberta is detailed by LGL

Ltd. (1986b). Tomm et al. (1981) provide detailed recommendations on the size and interspersion of habitat units in logged areas in Alberta, while Thomas et al. (1979) provide similar recommendations based largely on studies undertaken in the western United States.

9.0 MOOSE

9.1 GENERAL

Moose occur throughout Alberta with the exception of the grassland and most of the Aspen Parkland region (Soper 1964; A.F.W.D. 1984). The Mountain and Foothill biomes and the southern half of the Boreal Forest biome are classed as prime range, supporting on average 1-2 moose/km^2, but densities decrease on far northern ranges to an average of less than 0.3/km^2. An estimated 18,000 or more animals are harvested annually by recreational and native subsistence hunters (A.F.W.D. 1984).

9.2 FOOD

Moose are primarily browsers, the preferred species being characteristic largely of successional and riparian communities (Peek 1974). Browse --including leaf buds, leaves, twigs and sometimes bark-- is utilized throughout the year (Millar 1953; Flook 1964; Salt and Clarke 1979), although where available aquatic plants are used in summer (Millar 1953; Flook 1964; Soper 1970; Salt and Clarke 1979; Holroyd and VanTighem 1983). Forbs and gramineous plants appear to form only a small proportion of the total diet, although a fall stomach sample examined by Millar (1953) contained almost 100% gramineous material, suggesting that graminoids may be seasonally important at least to some animals. Salt and Clarke (1979) reported that in the Kananaskis area grasses are a staple food in winter.

In western North America willows are considered to be the most important browse species, both in terms of total forage production and utilization by moose (Kelsall and Telfer 1974; Peek 1974), and although food habits data are limited this generalization appears to hold true over most Alberta moose range (Millar 1953; Nowlin 1978; Usher 1978, 1981; Table 17). Aspen may also be a major dietary constituent where it comprises a large proportion of the browse available (Usher 1981). Minor forage producers, but nevertheless reported to be preferred where available, include saskatoon, low-bush cranberry, dogwood, choke cherry and pin cherry (Nowlin 1978; Usher 1978, 1981).

Studies in the Foothill and Boreal Forest areas have shown strong correlations between level of moose utilization of a site and the weight per unit area of winter browse available, but wide variation in use of areas with low browse production suggests that use may also be related to other factors such as early bud bursting or late leaf fall (Telfer 1978a). Although the upper feeding limit is normally about 2.5 m, moose can obtain additional winter food by by breaking stems of tall-growing species such as aspen, balsam poplar, willow and paper birch (Telfer and Cairns 1978).

9.3 COVER AND TERRAIN

Moose use a variety of cover and terrain types, but throughout their range are most strongly associated with areas where active processes such as alluvial and wind action, avalanches, impeded drainage, fire or logging have set back or arrested forest development (reviews by Rolley and Keith 1979, Thompson et al. 1980, Nietfeld et al. 1984). In the mountains, subalpine shrublands are used both summer and winter (Millar 1953; Flook 1964; Stelfox and Taber 1969; Nielsen 1973; Soper 1973; Holroyd and VanTighem 1983), but moose are rare (Soper 1970) or absent (Telfer 1978b) in the alpine zone, their altitudinal range being limited by excessive snow depths and lack of woody plants at high altitudes (Kelsall and Telfer 1974). Alluvial shrublands are probably the most important year-round habitat in both the Mountain and Foothill areas (Millar 1953;

Table 17. Food species used by moose in Alberta.

Species	Reference, Area and Diet Composition[1]					
	Clarke 1972 (Jasper)[2]	Millar 1953 (Rock Lake)[3]	Flook 1964 (Jasper/ Banff)[2]	Fitzmartyn and Holroyd 1978 (Lake Louise)[2]	Salt and Clarke 1979 (Kananaskis)[2]	Nowlin 1978 (AOSERP study area)[4]
Trees and Shrubs						
Abies lasiocarpa	x	0.6%	-	-	-	-
Abies spp.	-	xs	-	xw	x	-
Alnus crispa	-	0.9%w,x	-	-	-	2%w,xs
Amelanchier alnifolia	-	-	x	-	-	57%w,46%s
Betula spp.	x	0.3%w,xs	x	-	-	3%w,6%s
Cornus stolonifera	-	-	x	-	-	xs
Corylus cornuta	-	-	-	-	-	1%w,3%s
Juniperus spp.	-	xw	-	-	-	-
Menziesia glabella	-	-	-	-	x	-
Picea spp.	-	-	-	xw	x	-
Pinus contorta	-	3.2%w	-	xw	-	-
Populus balsamifera	-	0.7%w,xs	-	-	-	1%w
P. tremuloides	-	1.9%w,xs	x	-	-	2%w,7%s
Prunus spp.	-	-	x	-	-	xw,7%s
Rhododendron spp.	-	0.1%w	-	-	x	-
Ribes spp.	-	xw	-	-	-	-
Rosa spp.	-	xw	-	-	-	xs
Salix arbusculoides	-	xw	-	-	-	-
S. glauca	-	xw	xw	-	-	-
S. maccalliana	-	xw	xw	-	-	-
Salix spp.	x	90.8%w,xs	x	xw	x	30%w,28%s
Shepherdia canadensis	-	1.3%w,x	-	-	-	1%w
Viburnum edule	-	-	-	-	-	3%w,xs

..... Table 17 continued

Table 17 concluded.

Species	Clarke 1972 (Jasper)[2]	Millar 1953 (Rock Lake)[3]	Flook 1964 (Jasper/ Banff)[2]	Fitzmartyn and Holroyd 1978 (Lake Louise)[2]	Salt and Clarke 1979 (Kananaskis)[2]	Nowlin 1978 (AOSERP study area)[4]
	Reference, Area and Diet Composition[1]					
Graminoids						
Carex spp.	-	xs	xw,xs	-	x	-
Elymus spp.	-	xs	-	-	-	-
Gramineae	-	xw,xs	xw	-	x	-
Juncus spp.	-	xs	-	-	x	-
Typha spp.	-	-	-	-	x	-
Forbs, Horsetails and Aquatics						
Epilobium spp.	-	xs	-	-	-	-
Equisetum spp.	-	-	xs	-	-	-
Galium boreale	-	xs	-	-	-	-
Hippurus vulgaris	-	xs	xs	-	-	-
Lathyrus spp.	-	xs	-	-	-	-
Mertensia spp.	-	xs	-	-	-	-

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[1] x = present in diet; w = winter; s = spring-summer-fall (i.e., snow-free period).

[2] presence in diet based on general observations.

[3] dietary data based on browse plots, stomach samples and general observations.

[4] dietary data based on browse plots.

Salter and Hudson 1980; Mussell 1982; Holroyd and VanTighem 1983) due to their production of extensive stands of willow and other browse. Deciduous woods, mixed woods and several conifer forest types also are used in these biomes, both for escape and thermal cover and for foraging where suitable browse has developed (Millar 1953; Stelfox and Taber 1969; Soper 1970, 1973; Nielsen 1973; Telfer 1978b; Salter and Hudson 1980; Holroyd and VanTighem 1983).

In the Boreal Forest biome, muskegs, shrublands and deciduous, mixed and coniferous woodlands all are used, with use of lowland areas generally predominating during the snow-free period and use of upland forest cover increasing with increasing snow depth during mid- to late winter (Pendergast et al. 1974; Penner 1976; Salter and Koski 1979; Cairns and Telfer 1980; Rolley and Keith 1980; Hauge and Keith 1981; Mytton and Keith 1981). Open lowlands provide the first high quality forage in spring and may thus constitute critical habitat (Hauge and Keith 1981).

Although they generally avoid agricultural clearings, roads, dwellings and other disturbances (Rolley and Keith 1980; Mytton and Keith 1981; Ferguson and Keith 1982), moose will utilize cut-over areas provided that browse plants and escape cover are available (Usher 1978, 1981; Telfer 1978a; Stelfox 1981; Tomm et al. 1981).

Moose can tolerate greater snow depths than other cervids (Clarke 1942; Flook 1964; Telfer and Kelsall 1979) permitting them to winter in deep snow areas if good browse is available (Kelsall and Telfer 1974). Although snow depths of 70 cm may begin to impede moose movements (Kelsall 1969), snow depths encountered during a study in the foothills (up to 87 cm in open habitats) did not appear to restrict moose activities (Telfer 1978a); in the mountains, highest track densities were found in the 70-80 cm snow depth range, and tracks were found in snow as deep as 120 cm (Holroyd and VanTighem 1983). Most winter use occurs in flat areas, although south to west-facing slopes also are used (Stelfox 1978; Salt and Clarke 1979).

9.4 SPECIAL HABITAT FEATURES

In summer lakes and streams are used for refuge from biting flies (Flook 1959, 1964) and high temperatures (Kelsall and Telfer 1974). Summer movements to higher altitudes may serve the same purposes in some areas (Millar 1953).

Natural mineral licks are widely used in summer (Banfield 1947; Cowan and Brink 1949; Millar 1953; Best et al. 1977; Holroyd and VanTighem 1983), probably to satisfy requirements for sodium (Millar 1953; Best et al. 1977) and/or calcium (Jones and Hanson 1985). These licks may be an especially important feature of habitat in areas where other sources of sodium, such as aquatic vegetation, are not available (Best et al. 1977), and trips of from 1.5 to 16.5 km to visit licks have been documented (Millar 1953; Best et al. 1977). Moose also will eat soil that has been artificially impregnated with sodium chloride (Millar 1953) and they make some use of artificial salt licks (Holroyd and VanTighem 1983).

9.5 SPACE

Moose commonly undertake seasonal shifts between discrete summer and winter ranges, apparently in response to forage availability and snow depth, although some individuals remain within the same or overlapping areas year-round (Rolley and Keith 1979, 1980; Hauge and Keith 1981; Mytton and Keith 1981; Holroyd and VanTighem 1983). Data on home range size are not available from the mountains, where irregular altitudinal movements to higher ridges in summer and downward into sheltered valleys in winter occur (Millar 1953; Soper 1970). In the Boreal Forest of central Alberta, mean winter and summer home range sizes of 15 km^2 and 16 km^2 have been reported, separated by an average 13 km for males and 7 km for females (Mytton and Keith 1981). In northeastern Alberta, however, seasonal ranges of both males and females are usually each larger than 20 km^2 (Hauge and Keith 1981); in the Swan Hills, home range sizes are largest in winter, with a mean of 51.6 km^2 for males and 46.8 km^2 for females (Lynch and Morgantini 1984). Nonmigratory moose in northeastern Alberta occupied annual home ranges of 60-183 km^2, with a mean of 97 km^2 (Hauge and Keith 1981).

9.6 SIZE AND INTERSPERSION OF HABITAT UNITS

In Alberta the best moose habitat consists of an interspersion of young deciduous stands, muskeg and conifer forest (A.F.W.D. 1984). These vegetation types provide an optimal mix of foraging areas, escape cover and shelter, with conditions suitable for year-long use. By contrast extensive mature forests produce little browse and are not penetrated to any extent (Millar 1953; Stelfox et al. 1973).

Studies in the Foothills and Boreal Forest biomes have shown that logging of mature forests results eventually in an increased yield of browse, and provided that suitable cover is available, increased utilization by moose (Usher 1978, 1981; Stelfox 1981). An optimal balance of browse production and cover is predicted to occur 12-15 years after cutting in aspen/balsam poplar forest (Usher 1978), 15-20 years after cutting in lodgepole pine forest, and 25-30 or more years after cutting in spruce and mixedwood forests (Stelfox 1984). Other techniques, such as mechanical crushing of hardwood forests, result in immediate increases in browse availability and at least temporary attractiveness to moose (Sigman 1979). Although manipulation of browse availability can be used to influence local distributions of moose (Telfer 1978a), the size of area required for increases in browse production to be reflected in actual increases in moose populations is unknown. Telfer (1978a) suggested that if treatments are scattered throughout an area of 100 km^2 or more regional moose populations should increase.

In manipulated habitat, the size, shape and position of open areas in relation to forested stands are critical determinants of utilization by moose. In a long-term study in the Hinton area, residual blocks 101 x 101 m in size and interspersed throughout the clearcuts were shown to provide important escape cover and shelter for moose (Stelfox 1981). Tomm et al. (1981) found that the use of cutblocks by moose in the Foothill and Boreal Forest region of west-central Alberta was related to the size and interspersion of the cuts with residual blocks of mature timber and to levels of harassment. Moose favored cutblocks 41-80 acres (16.6-32.4 ha) in size, and buffered from adjoining openings by a 221-402 m width of residual forest, although blocks larger than 80 acres were used under low levels of harassment. Tomm et al. (1981) concluded that cutblock widths of 322-402 m and residual buffer widths of 101 m were compatible with moose production in areas of low harassment, but recommended that in areas of uncontrolled access and disturbance cutblock widths should be reduced to 121-161 m and priority placed on providing suitable cover. Usher (1978) provided more conservative guidelines based on studies in the Boreal Forest of east-central Alberta, where irregularly shaped cuts 2-5 ha in size, and not exceeding 100 m in width and 400 m in length, were recommended. If cutblocks are too large or if residual cover is removed moose avoid or use only the edges of cleared areas (Stelfox et al. 1973; Telfer 1978a; Tomm et al. 1981).

9.7 HABITAT MODELS

General reviews of habitat requirements, incorporating data from elsewhere in North America but with particular reference to Alberta conditions, have been prepared by Haywood and Shackleton (n.d.), Rolley and Keith (1979), Wallis and Wershler (1979), Thompson et al. (1980), Green et al. (1984), Nietfeld et al. (1984) and LGL Ltd. (1986a, 1986b). Wallis and Wershler (1979) and Norecol (1984) review food habits in relation to habitat reclamation requirements in western Canada. IEC Beak (1984d) provides a mathematical model for use in rating habitat suitability of land units throughout Alberta; models developed for study areas in northeastern and southwestern Alberta are provided by LGL Ltd. (1986a) and LGL Ltd. (1986b) respectively. A detailed summary of habitat requirements of moose in Alaska is currently in preparation and is available in draft form (U.S.F.W.S. 1984c).

10.0 ELK

10.1 GENERAL

The current distribution of elk in the province is limited primarily to the Mountain and Foothill biomes, and to a few outlying areas such as the Cypress Hills and the region surrounding Elk Island N.P. (Soper 1964; Stelfox 1964; A.F.W.D. 1984). Prime range is concentrated in the southwestern part of the province, south of the Clearwater River (A.F.W.D. 1984). Elk are a major game species and recreational viewing demand also is high (A.F.W.D. 1984).

10..2 FOOD

Elk in the Mountain and Foothill biomes subsist primarily on gramineous plants (Flook 1964; Salt and Clarke 1979; Morgantini and Hudson 1983). Browse is generally a relatively minor dietary constituent in winter (Cowan 1947; Flook 1964; Table 18), but increases in importance during summer-fall and on some midsummer ranges may provide the bulk of the diet (Flook 1964; Morgantini and Hudson 1983). Forbs are little used during any season (Table 18). Depredations on haystacks and greenfeed occur on ranches within and adjacent to the outer foothills (Banfield 1947; Alberta Fish and Wildlife Division n.d.a).

Fescues and sedges are by far the most important gramineous species in elk diets in the Mountain and Foothill region as a whole, although hairy wild rye and horsetails are locally important constituents (Stelfox et al. 1978; Holroyd and VanTighem 1983; Morgantini and Hudson 1983, 1985; Table 18). Willows are the most widely used and important browse species, but others such as pine, spruce, fir, silverberry, buffaloberry and aspen may be locally and/or seasonally important (Banfield 1947; Flook 1964; Stelfox et al. 1978; Salt and Clarke 1979; Morgantini and Hudson 1983; Table 18).

Forage selection during the growing season appears to be related to protein content (Morgantini and Hudson 1983), whereas during winter food selection may be related more to dry matter digestibility (Morgantini and Hudson 1985).

10.3 COVER AND TERRAIN

Elk are an opportunistic and highly adaptable species, occupying a broad range of habitat conditions even within a localized area. Habitat selection patterns are therefore difficult to generalize. On a coarse scale, elk habitat can be categorized as consisting of grasslands and shrublands interspersed with forested areas, and located in valley bottoms and on adjacent slopes and benches (Flook 1964; Soper 1970, 1973; Fitzmartyn and Holroyd 1978; Mussell 1982; Holroyd and VanTighem 1983). The altitudinal range of elk habitat in the Mountain and Foothill biomes extends from the outer (eastern) part of the Foothill zone to the lower alpine.

Observational and dietary data indicate that open and sparsely treed grassland communities provide the major foraging habitat (Morgantini 1979; Salter and Hudson 1980; Berg 1983; Morgantini and Russell 1983). Alpine tundra receives relatively less use (Stelfox et al. 1978; Holroyd and VanTighem 1983), but provides seasonally important and perhaps essential foraging habitat to local elk populations, due to the high protein content and digestibility of alpine plants (Morgantini and Hudson 1983; Morgantini 1984). Shrublands and a variety of deciduous, coniferous and mixedwoods forests also are used for feeding to some extent (Nielsen 1973; Telfer 1978b; Morgantini 1979; Salter and Hudson 1980; Berg 1983; Morgantini and Olsen 1983). Both forest cover and hilly terrain

Table 18. Food species used by elk in Alberta.

Species	Reference, Area and Diet Composition[1]						
	Berg 1983 (upper Oldman R.)	Salter and Hudson 1980 (upper Red Deer R.)[3]	Morgantini & Hudson 1983 (YaHa Tinda Ranch/Banff)[4]	Morgantini and Russell 1983 (upper Red Deer R.)[5]	Morgantini and Russell 1983 (upper Clearwater R.)[6]	Morgantini and Russell 1983 (upper Blk-stone R.)[7]	Morgantini and Olson 1983 (Wolf Creek-Brazeau R.)[8]
Trees and Shrubs							
Amelanchier spp.	-	-	-	1.2%w	0.1%w	-	-
Artemisia spp.	0.2%w	-	-	0.4%w	1.3%w	-	-
Browse	-	-	2.2%w/s,0.2%s	-	-	1.0%w	25.5%w
Juniperus spp.	0.4%w	-	-	1.0%w	-	-	-
Pinus contorta	-	22%w	-	-	-	-	-
Pinus spp.	-	-	-	0.7%w	2.4%w	3.8%w	-
Picea spp.	0.1%w	xw	-	1.6%w	0.8%w	6.8%w	-
Pseudotsuga spp.	3.7%w	-	-	-	0.3%w	-	-
Rubus spp.	<0.1%w-	-	-	-	-	-	
Salix spp.	<0.1%w	19%w	1.5%w/s,88.6%s	8.1%w	7.2%w	11.6%w	-
Shepherdia canadensis/ Elaeagnus commutata	<0.1%w	xw	-	2.4%w	1.0%w	1.4%w	-
Vaccinium spp.	-	-	-	-	-	0.6%w	-
Graminoids							
Agropyron spp.	0.2%w	-	-	-	-	-	-
Agropyron/Elymus	-	-	-	2.5%w	3.7%w	6.2%w	-
Agrostis scabra		-	-	-	-	-	-
Bouteloua spp.	0.2%w	-	-	-	-	-	-
Bromus spp.	0.1%w	-	-	-	0.1%w	-	-
Carex spp.	2.6%w	9%w	-	19.4%	16.6%w	19.2%w	-
Cyperaceae	-	-	4.2%w/s,2.4%s	-	-	-	40.3%w
Danthonia intermedia	-	1%w	-	0.2%w	0.2%w	1.2%w	-
Danthonia spp.	4.8%w	-	-	-	-	-	-
Deschampsia spp.	-	-	-	-	1.6%w	8.5%w	-
Eleocharis spp.	-	-	-	0.1%w	-	-	-

..... Table 18 continued

Table 18 continued.

Species	Reference, Area and Diet Composition[1]						
	Berg 1983 (upper Oldman R.)	Salter and Hudson 1980 (upper Red Deer R.)[3]	Morgantini & Hudson 1983 (YaHa Tinda Ranch/Banff)[4]	Morgantini and Russell 1983 (upper Red Deer R.)[5]	Morgantini and Russell 1983 (upper Clearwater R.)[6]	Morgantini and Russell 1983 (upper Blk-stone R.)[7]	Morgantini and Olson 1983 (Wolf Creek-Brazeau R.)[8]
Elymus innovatus	-	19%w	0.6%w/s,1.7%s	-	-	-	-
Elymus spp.	<0.1%w	-	-	-	-	-	-
Festuca spp.	85.2%w	21%w	88.2%w/s,0.4%s	52.8%w	60.5%w	20.3%w	-
Gramineae	<0.1%w	-0.9%w/s,0.5%s	-	-	-	13.4%	
Juncus spp.	-	-	-	0.2%w	0.3%w	1.2%w	-
Koeleria cristata	0.3%w	xw	-	0.6%w	0.8%w	1.4%w	-
Poa spp.	0.9%w	-	0.2%w/s,1.3%w	1.9%w	1.4%w	1.6%w	-
Schizachne purpurascens-	xw	-	-	-	-	-	
Stipa spp.	1.0%w	-	-	0.6%w	-	-	-
Forbs							
Astragalus spp	-	xw	-	-	-	0.3%w	-
Compositae	<0.1%w	-	-	-	0.1%w	-	-
Delphinium spp.	-	-	-	0.1%w	<0.1%w	0.3%w	-
Draba spp.	-	-	-	-	-	0.3%w	-
Forb	-	-	2.0%w/s,3.2%s	-	-	-	3.9%w
Galium spp.	-	-	-	0.6%w	-	-	-
Lupinus spp.	<0.1%w	-	-	-	-	-	-
Mertensia spp.	-	-	-	-	-	0.6%w	-
Petasites spp.	-	-	-	-	-	-	-
Potentilla/Geum spp.	-	2%w	-	-	-	-	-
Saxifraga spp.	-	-	-	-	0.1%w	-	-
Stellaria spp.	-	-	-	-	0.1%w	-	-
Vicia spp.	-	-	-	-	0.1%w	0.4%w	-

..... Table 18 continued

Table 18 concluded.

Species	Reference, Area and Diet Composition[1]						
	Berg 1983 (upper Oldman R.)	Salter and Hudson 1980 (upper Red Deer R.)[3]	Morgantini & Hudson 1983 (YaHa Tinda Ranch/Banff)[4]	Morgantini and Russell 1983			Morgantini and Olson 1983 (Wolf Creek-Brazeau R.)[8]
				(upper Red Deer R.)[5]	(upper Clearwater R.)[6]	(upper Blk-stone R.)[7]	
Horsetails, Club-mosses and Mosses							
Equisetum spp.	-	<1%w	-	4.8%w	1.1%w	11.0%w	15.8%w
Lycopodium spp.	-	-	-	0.2%w	-	-	-
Moss	-	-	-	-	0.1%w	-	-
Selaginella spp.	-	-	-	0.2%w	-	1.1%w	-
Lichens	-	xw	-	-	-	0.4%w	-

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[1] x = present in diet; w = winter (October-March, or part thereof); s = spring-summer-fall (April-September, or part thereof). All diet compositions determined from identification of plant cuticular fragments in composite fecal samples.

[2] fecal samples collected during winter (months not specified).

[3] fecal samples collected January, February, March.

[4] fecal samples collected monthly on winter range (December-May: w/s) and summer range (July-August: s).

[5] fecal samples collected November, December, January, March.

[6] fecal samples collected monthly November-March.

[7] fecal samples collected December and March.

[8] fecal samples collected monthly December-March, in each of 2 years. Browse in diet consisted mainly of Salix spp., Equisetum spp. includes Pminor amounts of other genera.

are used for escape and shelter (Flook 1964; Stelfox and Taber 1969; Soper 1970; Telfer 1978b; Morgantini 1979; Holroyd and VanTighem 1983).

Natural disturbances such as fire and avalanches appear to be important in the maintenance of elk habitat (Flook 1970; Holroyd and VanTighem 1983). Elk also utilize logged areas once suitable forage cover and shelter have developed (Stelfox 1981) and make some use of seeded grasslands (Stelfox and Jasper National Park Warden Service 1974; Sullivan and Stelfox 1974; Stelfox et al. 1978) and other reclaimed areas (Kuhn and Martens 1980).

Elk are associated primarily with gently to moderately sloping terrain (i.e., slopes of 30% or less), although steeper, vegetated slopes also are used (Morgantini 1979; Salter and Hudson 1980; Strong and Vriend 1980; Berg 1983). Predominant use occurs on west, south and east exposures (Nielsen 1973; Stelfox and Jasper National Park Warden Service 1974; Strong and Vriend 1980; Berg 1983), with use shifting from western aspects in winter to eastern aspects in spring (Berg 1983).

During winter elk concentrate in areas of reduced snow depth, generally avoiding sites with accumulations of more than 50-60 cm (Telfer 1978a; Holroyd and VanTighem 1983). West to south-facing grassland slopes and valley bottoms, where snow accumulations are reduced or periodically removed by wind and sun action, are particularly important winter habitats (Flook 1970; Telfer 1978a; Morgantini 1979; Salter and Hudson 1980; Strong and Vriend 1980; Morgantini and Russell 1983).

10.4 SPECIAL HABITAT FEATURES

Elk in the Mountain and Foothill biomes make use of natural mineral licks (Cowan and Brink 1949; Carbyn 1975; Holroyd and VanTighem 1983), but their importance is poorly understood and they may not be essential features of habitat (Skovlin 1982). Other mineral sources, such as salt grounds established for cattle and drillhole seepages at mine sites, also are used (Kuhn and Martens 1980; Berg 1983).

10.5 SPACE

Elk exhibit seasonal shifts in habitat use related to snow depth, floral phenology and nutritional factors (Flook 1964; Soper 1970, 1973; Nielsen 1973; Strong and Vriend 1980; Morgantini and Hudson 1983). In the mountains seasonal movements may involve round-trip distances of up to 138 km, and total vertical movements of 2000 m (Flook 1964; Morgantini and Hudson 1983; Morgantini 1984). Overnight vertical movements of 600 m over a linear distance of 9 km have been documented, but most movement occurs as a gradual shift between restricted winter range and more widely dispersed summer range (Morgantini and Hudson 1983). Valley bottoms appear to be the major movement corridors (Banfield 1947; Morgantini and Hudson 1983).

Some elk populations, or segments of populations, apparently forego altitudinal migrations (Flook 1964; Strong and Vriend 1980), satisfying habitat requirements by remaining in areas of high vegetational heterogeneity (Morgantini and Olsen 1983).

10.6 SIZE AND INTERSPERSION OF HABITAT UNITS

Good elk habitat consists of open forage-producing sites interspersed with forest areas and/or geomorphic features providing escape and thermal cover. Winter ranges receiving highest use in southern Alberta consist of 60-75% foraging area, with thermal and hiding cover comprising the remainder (Strong and Vriend 1980). Forage:cover ratios of 60:40 have been described as optimal elsewhere (Black et al. 1975). Also in southern Alberta, Berg (1983) characterized key elk range sites as being small (probably <25 ha each, but sites may be contiguous), often snow-free, and in open grassland adjacent to grass/conifer range.

Use of foraging areas varies with distance to cover and with disturbance factors (Morgantini 1979; Berg 1983; Morgantini and Russell 1983). Berg (1983) found that almost all elk activity (100% of observations, 99.6% of pellet groups) occurred within 250 m of tree or shrub cover, and that elk on grassland range were most likely to react to disturbance when 100-250 m from cover. Morgantini (1979) and Morgantini and Hudson (1980) documented a redistribution of elk in relation to severe disturbance (vehicular and human activity during a special winter hunting season) that resulted in a 70% decrease in grassland use; a corresponding shift in forage intake resulted in increased use of browse and forest grasses, and decreased diet digestibility (Morgantini and Hudson 1985).

Considering the dependence of elk on limited, traditional wintering areas, Telfer (1978a) suggested that road networks and other disturbances (e.g., logging) in the foothills be sited to avoid key winter ranges, and if possible be screened by topographic features.

10.7 HABITAT MODELS

Reviews of elk forage and habitat requirements are provided by Wallis and Wershler (1979), Skovlin (1982), Nietfeld et al. (1984), Norecol (1984) and LGL Ltd. (1986b). The reviews by Wallis and Wershler and Norecol focus specifically on habitat reclamation in western Canada. IEC Beak (1984e) provides a model for rating habitat suitability of broad-scale land units for elk in Alberta; a similar model for a study area in southwestern Alberta is provided by LGL Ltd (1986b). Leege (1984) outlines a tabular method for estimating quality of elk summer habitat in northern Idaho, and for evaluating effects of land management activities.

11.0 MOUNTAIN GOAT

11.1 GENERAL

In Alberta mountain goats are confined to high, rugged terrain along the east slopes of the Rockies, where they occupy a discontinuous range from Waterton Lakes in the south to the Grand Cache (Kakwa River) area in the north (Soper 1964; A.F.W.D. 1984). The total provincial population has been estimated at 2000 to 2500 animals, with half or more of these being found in Banff and Jasper N.P. (McFetridge 1977a). This population sustains limited recreational hunting and viewing (A.F.W.D. 1984).

11.2 FOOD

Mountain goats consume a varied diet consisting of alpine grasses and forbs and the leaves and twigs of several tree and shrub species (Soper 1964; Kerr 1965; McFetridge 1977a; Salt and Clarke 1979; Table 19). Diet quality varies seasonally (McFetridge 1977a), but only gross trends in seasonal species composition can be discerned from available data. Deciduous browse and forbs together dominate reported monthly diets. Grasses are used throughout the year and during summer may comprise up to 54% of monthly diets (McFetridge 1977a) and 80% of individual stomach contents (Kerr 1965). Gramineous species used include wheatgrasses, bromes, sedges (including Carex nardina), rough fescue, hairy wild rye and june grass (Salt and Clarke 1979). Among browse species the Elaeagnaceae (silverberry and possibly buffalo-berry) appear to be particularly important and constant dietary constituents, both on a seasonal and area to area basis (Soper 1964; Kerr 1965; McFetridge 1977a). Coniferous browse is generally used in trace or very minor amounts, although exceptionally individual goats may take quantities of subalpine fir (Kerr 1965).

11.3 COVER AND TERRAIN

Mountain goats occur primarily in the upper subalpine and alpine zones, where they are found in association with mosaics of grass/forb meadows and tundra, low shrublands, and broken, steep slopes and cliffs (Banfield 1947; Flook 1964; Soper 1964, 1970, 1973; Nielsen 1973; McFetridge 1977a; Holroyd and VanTighem 1983). They also make some use of open forest (both deciduous and coniferous) at timberline and travel along well-defined routes through subalpine and montane forests to reach mineral licks (Soper 1964, 1970, 1973; McFetridge 1977a; Holroyd and VanTighem 1983). The use of sandstone/shale bluffs by a goat population along Pinto Creek (east of the main mountain ranges) appears to be anomalous, but may be indicative of some plasticity in habitat use by this species; in this area goats are confined to a narrow belt, about 200 yards (183 m) wide on each side of the creek, consisting of low shrubland, grassland and cliffs bordered above by white spruce-lodgepole pine forest (Kerr 1965). Proximity to escape terrain in the form of steep slopes or cliffs is a key determinant of habitat use in all areas (Kerr 1965; Stelfox and Taber 1969; McFetridge 1977a; Holroyd and VanTighem 1983). Cliffs also are important as bedding and kidding areas (McFetridge 1977b).

Burned subalpine meadows and slopes provide foraging areas with relatively high plant biomass production, and may be of particular importance to nursery groups (McFetridge 1977a). Although fire-produced habitats may be of less significance to goats than to other ungulates (Flook 1964), fire suppression is believed to result in habitat deterioration and reduction in carrying capacity for goats (Johnson 1977). The use of avalanche paths (Flook 1964; Holroyd and VanTighem 1983) may similarly be related to selection for the secondary vegetation occurring in such areas.

Table 19. Food species used by mountain goats in Alberta.

Species	Reference, Area and Diet Composition[1]	
	Kerr 1965 (Smoky R. area)[2]	McFetridge 1977a (Smoky R. area)[3]
Trees and Shrubs		
Abies lasiocarpa	0-1.3%w,xs	-
Alnus spp.	1.7-5.7%w,xs	-
Almelanchier alnifolia	3.9-52.4%w	-
Arctostaphylos uva-ursi	xw,xs	x
Betula spp.	-	x
Coniferae	-	1-4%w,0-1%s
Elaeagnaceae	-	1-34%w,4-46%s
Elaeagnus commutata	17.5-31.6%w,xs	-
Lonicera spp.	0-0.5%w	-
Pinus contorta	0-0.5%w	-
Populus tremuloides	6.5-31.3%w	-
Ribes spp.	xw	-
Rosa spp.	2.3-30.9%w	-
Rubus spp.	0-0.3%w	-
Salix spp.	tr-5.0%w,xs	1%w,0-6%s
Shepherdia canadensis	xw	-
Symphoricarpos albus	0-3.6%w	-
Viburnum edule	0-3.9%w	-
Graminoids		
Cyperaceae	-	1-3%w,0-5%s
Gramineae	xw,xs	26-43%w,10-54%s
Forbs and Horsetails		
Arnica spp.	-	x
Equisetum spp.		- 0-1%w
Erigeron spp.	-	x
Forb	xw,xs	35-64%w,26-73%s
Leguminosae	-	x

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[1] x = present in diet; w = winter; s = spring-summer-fall.

[2] percent winter diets determined from browse use along range transects Mt. Hamell and Pinto Creek (percentages refer to total winter diets each area). Additional presence/absence data from stomach samples collected December (n=2) and June-August (n=4).

[3] percent diets determined from fecal fragments analysis on feces collected each monthMay-August (summer) and October, November and February (winter). Percentages refer to range of monthly values. Forb class includes some browse.

Suitable habitat is most restricted during winter, when goats are concentrated on areas of steep, broken terrain where wind and sun action reduce snow depths and leave potential forage exposed (Banfield 1947; Kerr 1965; Holroyd and VanTighem 1983). Most winter ranges are located on south to west-facing slopes or ridgetops (Kerr 1965; Stelfox 1978; Holroyd and VanTighem 1983).

Spring-summer-fall range is more extensive (Kerr 1965) and most use of alpine meadows and forested areas is made at this time (Hall 1977; Holroyd and VanTighem 1983). Most use occurs on steep slopes (>45°), but moderate and even gentle slopes (<30°) are used, the latter primarily for feeding (McFetridge 1977a). Predominant use of east, south and north slopes has been documented for the spring to fall period (Nielsen 1973; McFetridge 1977a).

During summer, goats use well-established bedding grounds exposed to sun and wind (Kerr 1965); they may also lie-out on snowbanks (Holroyd and VanTighem 1983) or use overhangs and small caves for shade (Holroyd and VanTighem 1983). Sheltered areas are sought during rain and snow flurries (Kerr 1965). Use of old mine portals for shelter has been documented in British Columbia (McCrory et al. 1977).

11.4 SPECIAL HABITAT FEATURES

Natural mineral licks are widely used in spring and summer (Cowan and Brink 1949; McCrory 1969; Salt and Clarke 1979; Holroyd and VanTighem 1983), apparently as a source of sodium (Hebert and Cowan 1971). Kerr (1965) suggested that mineral licks were not a necessary requirement of goat range, but well-documented treks to lick areas (McCrory 1969; Soper 1970, 1973; Holroyd and VanTighem 1983), often through heavy forest and at considerably increased risk of predation, suggests a strong motivation for lick use.

Mountain goats can contact contagious ecthyma, which in bighorn sheep has been linked to prolonged use of areas where salt has been provided artificially (Samuel et al. 1975).

11.5 SPACE

Mountain goats are relatively sedentary, and except for movements of up to several kilometers to mineral licks they remain within restricted home ranges year-round (Soper 1964, 1970). Although seasonal movement patterns are not well understood (Hall 1977) they appear to consist mainly of short-range altitudinal shifts, and wintering ranges may overlap or be included within summering ranges (Banfield 1947; Stelfox and Taber 1969; Holroyd and VanTighem 1983). Kerr (1965) noted a downward shift in spring that was probably a response to new vegetation growth, followed by a gradual upward movement through the summer (again following new growth) and a downward shift back to winter range initiated by the first snowfalls, all within a maximum horizontal distance of about 4.8 km. There appears to be some sexual segregation, with adult males found in summer in different areas than females and immatures (Banfield 1947; Soper 1973; McFetridge 1977a; Salt and Clarke 1979).

Home range size data apparently are not available for Alberta, although McFetridge (1977a) speculated that individual goats may remain within areas no larger than 25 km^2 during their entire lifespan. This agrees well with mean yearly ranges of 21.5 km^2 for male and 24.0 km^2 for female goats in Montana (Rideout 1974).

11.6 SIZE AND INTERSPERSION OF HABITAT UNITS

Habitat use by mountain goats is circumscribed primarily by the distance they will travel from secure escape terrain. Studies in the Grande Cache area (McFetridge 1977a) suggest that most use (80% of his observations) can be expected to occur within 200 m of escape terrain, and virtually all use (95% of observations) within about 400 m. As goats do not normally forage beyond this limit the interspersion of escape terrain within forage producing habitat, rather than forage production per se, can be considered the critical determinant of carrying capacity for this species.

Proximity of development activities and human access have recently become increasing concerns in management of goat habitat. Increased road access and overhunting have been implicated in population declines in several areas of Alberta and British Columbia and concern has been expressed about the effects of increasing levels of resource exploitation in mountain goat areas (McFetridge 1977a, 1977b; Pendergast and Bindernagel 1977). Reviewing the situation in North America in general, Johnson (1977) concluded that logging and mining activities contributed both to direct destruction of goat habitat and to disturbance of goat populations, resulting in movement away from traditional areas. Habitat destruction has not been identified as an important factor in known declines in British Columbia, but may be a factor in attempts to re-establish populations post-mining (Pendergast and Bindernagel 1977). Conversely, reclamation of goat ranges could at least potentially result in habitat improvement by expanding refuge areas (McFetridge 1977a).

11.7 HABITAT MODELS

Habitat requirements of mountain goats are reviewed by Nietfeld et al. (1984) as part of a model prepared for use in habitat suitability rating in Alberta (IEC Beak 1984f).

12.0 BIGHORN SHEEP

12.1 GENERAL

In Alberta bighorn sheep are confined to the Rocky Mountains, where they occupy a long, narrow strip of habitat centering on the subalpine and alpine zones (Soper 1964; A.F.W.D. 1984). A potential habitat area estimated at 35,000 km^2 is populated by approximately 9000 sheep, with both habitat and sheep numbers about equally divided between the mountain national parks and adjacent provincial lands (Stelfox 1971, 1976a, 1978; A.F.W.D. n.d.b). Bighorn sheep are an important trophy species and also are sought for recreational viewing (A.F.W.D. 1984).

12.2 FOOD

Bighorn sheep utilize a variety of gramineous, forb and low shrub species, depending on range composition and time of year (Table 20). Grasses and shrubs are used year-round, whereas forbs are used mainly during late spring-early fall (Stelfox 1976a) when in some areas they may become the most important forage component (Wishart 1958). There appears to be a negative correlation between range condition and forb and shrub utilization, with most forb and shrub use occurring on heavily grazed ranges (Stelfox 1976a). Stelfox (1976a) reported average diet compositions of 74% gramineous plants, 23% forbs and 4% shrubs on six major ranges in the national parks, confirming results of an earlier, more limited study which estimated that grasses and sedges comprised 83% of the winter diet in Jasper (Cowan 1947). Subsequent studies in Banff have reported winter diets averaging 94% grasses and sedge (Shank 1982).

Fescues, wheatgrasses, june grass and sedges are probably the most important gramineous species in sheep diets on a provincial range-wide basis, although others are utilized (Table 20). Forb selection is more difficult to generalize, but it is noteworthy that the Compositae and Leguminosae are well represented in known diets.

12.3 COVER AND TERRAIN

On a broad scale, bighorn sheep are associated with grasslands and rocky escarpments throughout the year (Flook 1964; Stelfox and Taber 1969; Stelfox 1976a; Holroyd and VanTighem 1983). Seasonal habitat use spans a number of plant associations and physiographic situations, from open valley bottoms and isolated grasslands within the coniferous forest (montane) zone to grass, forb and heath-dominated subalpine/alpine meadows and slopes (Wishart 1958; Flook 1964; Soper 1964, 1973; Stelfox and Taber 1969; Nielsen 1973; Johnson 1975; Holroyd and VanTighem 1983) to artificially seeded grasslands (as along highway aprons: Sullivan and Stelfox 1974). They also make some use of moist open forests of subalpine fir, larch and Engelmann spruce, of open Douglas fir and mixed conifer forests, of deciduous forests, and of upper subalpine shrub communities on avalanche slopes and colluvial aprons (Wishart 1958; Flook 1964; Nielsen 1973; Morgantini 1979; Holroyd and VanTighem 1983). Forests are used primarily along the edges for limited feeding and thermal cover. Steep, broken terrain and talus slopes are key habitat features used for bedding, escape and lambing (Wishart 1958; Stelfox and Taber 1969; Nielsen 1973; Morgantini 1979; Holroyd and VanTighem 1983).

Periodic fire appears to be an important feature of sheep habitat, functioning both in increasing the extent of grassland (or setting back forest encroachment on existing grasslands) and recycling nutrients into new forage growth (Flook 1964; Soper 1973; Stelfox 1976a, 1978; Bentz 1981).

Table 20. Food species used by bighorn sheep in Alberta.

	Reference, Area and Diet Composition[1]		
Species	Wishart 1958 (Sheep R.)[2]	Stelfox 1976a (Jasper, Banff, Waterton N.P.)[3]	Shank 1982 (Banff N.P.)[4]
Trees and Shrubs			
Alnus tenuifolia	xs	-	-
Amelanchier alnifolia	xs	xw,xs	-
Arctostaphylos uva-ursi	xs	0-11.1%s,xw	-
Cornus stolonifera	-	xs	-
Elaeagnus commutata	xs	-	-
Picea glauca	xs	-	-
Picea spp.	-	-	0.6%w
Populus tremuloides	xs^{H}	-	-
Potentilla fruticosa	xs	0-42.8%s,xw	-
Prunus spp.	-	xw,xs	-
Ribes setosum	xs^{H}	-	-
Rosa acicularis	xs	0-4.5%s,xw	-
Salix spp.	xs^{H}	xw,xs	-
Sambucus spp.	xs	-	-
Shepherdia canadensis	xs	xs	-
Graminoids			
Agropyron spp.[5]	xs^{H}	0-23.3%s,xw	-
Agrostis spp.	xs	-	-
Bromus pumpellianus	-	0-2.9%s	-
Bromus spp.	xs	xs	4.1%w
Calamagrostis spp.	-	0-4.3%s,xw	-
Carex spp.	xs^{H}	xw	9.2%w
Danthonia spp.	-	xw,xs	-
Elymus innovatus	xs	0-2.9%s,xw	-
Elymus spp.	-	-	2.8%w
Festuca idahoensis	-	0-17.2%s	-
F. scabrella	xs^{H}	0-80.1%s	-
Festuca spp.	-	xw,xs	71.4%w
Juncus spp.	-	xw,xs	-
Koeleria cristata	xs^{H}	0-14.5%s,xw	4.6%w
Phleum pratense	xs	-	-
Poa spp.		0-4.7%w	1.9%w
Forbs			
Achillea millefolium	-	xs	-
Agoseris spp.	xs	-	-
Anemone spp.	xs	xs	-
Artemisia frigida	-	xw,xs	-

..... Table 20 continued

Table 20 concluded.

Species	Reference, Area and Diet Composition[1]		
	Wishart 1958 (Sheep R.)[2]	Stelfox 1976a (Jasper, Banff, Waterton N.P.)[3]	Shank 1982 (Banff N.P.)[4]
Aster spp.	-	0-13.6%s	-
Astragalus spp.	xs^H	xs	0.6%w
Campanula rotundifolia	-	0-7.0%s	-
Castilleja spp.	xs	-	-
Cirsium spp.	xs^H	-	-
Compositae	-	-	0.7%w
Delphinium spp.	xs^H	-	-
Dodecatheon cusicki	xs	-	-
Equisetum spp.	xs	-	-
Erigeron spp.	-	xs	-
Forb	-	-	1.2%w
Fragaria glauca	xs	-	-
F. virginiana	-	0-1.4%s	-
Galium boreale	-	0-9.1%s	-
Hedysarum spp.	xs^H	xs	-
Hieracium spp.	-	xs	-
Oxytropis spp.	xs^H	xs	-
Phacelia sericea	-	0-1.4%s	-
Potentilla spp.	xs	-	-
Senecio spp.	-	xs	-
Silene parryi	-	xs	-
Smilacina spp.	xs	-	-
Solidago spp.	-	0-11.1%s	-
Taraxacum officinale	-	xs	-
Trifolium spp.	-	xs	-
Zygadenus spp.	xs	-	-

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[1] x = present in diet; w = winter; s = spring-summer-fall.

[2] diet composition determined from range transects examined April-September. Species receiving high to moderate use during any season are marked with the superscript ^{H}.

[3] percent diet composition estimated from plant utilization along range transects July-early August; additional data obtained from transects examined during spring, fall and winter. Percentages refer to range of values from six separate areas.

[4] percent diet composition determined from fecal fragments analysis on feces collected November-April.

[5] includes *A. dasystachyum*, *A. trachycaulum* and *A. spicatum*.

Habitat use during the spring-summer-fall period is strongly related to forage quality. Wishart (1958), Stelfox and Taber (1969) and Stelfox (1978) outlined the following generalized pattern: during April and May sheep concentrate on low, south-facing slopes and valley bottoms where the first new plant growth occurs; in May and June they forage upward along south and east slopes to subalpine and alpine grasslands (with females moving to rugged escarpments on south and east exposures for lambing); in July and August they forage on south and west slopes at high elevation and along alpine valley bottoms following receding snowfields; in late August and September they shift to north-facing grasslands and semi-open forests again following snow-melt and seeking the most succulent vegetation; in September and October, subsequent to the first frosts and snowfall, they begin to drift downward to wintering areas.

During winter, bighorns are confined largely to steep south or west-facing slopes where sun and wind action keep forages exposed (Flook 1964; Soper 1964; Geist 1971; Stelfox 1971, 1978; Geist and Petocz 1977) although in Waterton Lakes N.P. the major winter use occurs on north and northeast-facing slopes (Nielsen 1973; Stelfox 1978). Windblown tundra and alpine meadows also are used (Holroyd and VanTighem 1983), but flat areas are avoided (Stelfox 1978). Sheep generally avoid snow depths in excess of 30 cm, and this greatly restricts the extent of available winter range (Stelfox 1976a). They move away from south and west-facing slopes into more sheltered areas, including caves and thick stands of subalpine timber, to avoid major storms (Soper 1964; Stelfox 1976a) and appear to make use of altitudinal thermoclines, which provide higher ambient temperatures and reduced temperature fluctuations (Geist 1972; Stelfox 1976a).

12.4 SPECIAL HABITAT FEATURES

Bighorn sheep make frequent use of natural mineral licks, primarily during summer (Cowan and Brink 1949; Wishart 1958; Soper 1964, 1970, 1973; McCrory 1969; Stelfox 1978; Wishart et al. 1980; Holroyd and VanTighem 1983). Lick use appears to be related to the lambing and moulting periods (Stelfox 1978), and although use has been variously attributed to a need for sodium (Wishart 1958), calcium (Jones and Hanson 1985) or copper, calcium and phosphorous (Stelfox 1978), the nutritional significance of licks remains poorly understood.

Bighorns also make use of other mineral sources, such as salt blocks, highway salt and minerals spilled from trains (Wishart 1958; Stelfox 1978). Use of artificially provided salt has been linked with the spread of contagious ecthyma, a potentially debilitating disease (Samuel et al. 1975; Stelfox 1976b; Lance 1980).

12.5 SPACE

As noted above bighorns undertake seasonal altitudinal movements between summer and winter range and also make periodic visits to mineral licks, some of which may be in heavily forested areas well away from normal foraging habitat (Soper 1964, 1970; Stelfox 1976a; Morgantini 1979). Wishart (1958) documented seasonal movements of between 8 and 25 mi (13-40 km) between summer and winter ranges, although in some cases seasonal ranges overlap. Rams also undertake long-distance movements related to the rut; these may be 15 mi (24 km) or more in extent (Geist 1971).

Sheep are loyal to their home ranges on a year-to-year basis and movements between them are predictable (Geist 1971). Geist (1971) identified up to seven seasonal home ranges occupied by individual rams and up to four seasonal ranges used by individual ewes, with minimum range sizes of approximately 0.5 mi (0.8 km) diameter in midwinter and maximum home range sizes up to 3.7 mi (6.0 km) in diameter in spring and fall.

The sexes remain segregated for much of the year, even when occupying spatially contiguous ranges (Soper 1964; Geist 1971; Nielsen 1973; Geist and Petocz 1977; Morgantini and Hudson 1981; Shank 1982).

12.6 SIZE AND INTERSPERSION OF HABITAT UNITS

Bighorn sheep require open, primarily non-forested habitat for foraging and adjacent steep, broken terrain for escape, bedding, lambing and refuge from deep snow cover. Adjacent forests may be used to some extent for foraging and for thermal cover and are passed through during seasonal movements, but adequate areas of open, secure terrain are the major feature of habitat required by this species. The interdependence of traditional summer and winter ranges may limit the gross distribution of bighorn sheep (Soper 1970).

Proximity to escape terrain appears to be a major determinant of habitat use. Although quantitative data are not available from Alberta, information reviewed by Van Dyke et al. (1983) indicates that cliffs should be at least 8 m high by 200 m long for escape, bedding and thermal use and should be at least 2 ha to serve as a lambing area. Bighorn sheep in Jasper have been observed feeding up to 0.5 mi (0.8 km) from escape terrain (Flook 1964); in general they make primary use of forage areas within 0.8 km and are not seen further than 1.6 km from potential escape areas (Van Dyke et al. 1983). Further indirect evidence for the importance of escape terrain is the observation that heart rate (and thus, presumably, level of stress) is lower in bighorns feeding on slopes of 10 to 34° than in open meadows of 0 to 6°, or passing through forest (MacArthur et al. 1982) and Wishart's (1958) and Geist's (1971) observations that migrating sheep show extreme caution when crossing flats or entering timbered areas.

Carrying capacity of foraging habitat (and thus size of area required by a given herd) varies with floral composition and period of use, as well as with interspersion of escape terrain. Stelfox (1976a) calculated grazing capacities of 3.2 to 5.9 sheep-months/ha on national park ranges.

Bighorn sheep are sensitive to human disturbance (Soper 1964; Morgantini 1979; MacArthur et al. 1979, 1982; Wishart et al. 1980) and are considered to be one of the least adaptable species to habitat disruption (Anonymous 1972). As a result, concern has been expressed about the effects of coal-mining and associated activities on Alberta sheep ranges (Anonymous 1972; Etter 1972, 1973). Although bighorns habituate to humans in areas protected from hunting (Soper 1964; Geist 1971) and to some extent to vehicular traffic at least 200 m away (MacArthur et al. 1979, 1982), they are traditional in their area use patterns and cannot withstand destruction of critical habitat by moving elsewhere.

Etter (1972, 1973) discusses the critical importance of winter range to this species and outlines preliminary approaches to habitat reclamation. He suggests establishment of grasses and forbs on south-facing slopes and of shrubs and trees on north-facing slopes, with priority given to southerly slopes of 10 to 20°. However, south-facing slopes of up to 35°, with appropriate areas of steeper, broken escape terrain, may more closely mimic both natural grassland habitat (Stelfox 1976a) and slopes actually used by bighorns (Morgantini 1979; MacArthur et al. 1982).

12.7 HABITAT MODELS

Nietfeld et al. (1984) review the North American literature as part of a model prepared for rating habitat suitability for bighorns in Alberta (IEC Beak 1984g). Wallis and Wershler (1979) and Norecol (1984) review food habits and habitat requirements relevant to habitat reclamation in western Canada. Habitat requirements also are reviewed in detail by Van Dyke et al. (1983), primarily with reference to habitat management in the Great Basin region.

13.0 SPRUCE GROUSE

13.1 GENERAL

Spruce grouse are locally resident in coniferous forest areas throughout western and northern Alberta (Salt and Salt 1976; A.F.W.D. 1984). They are harvested by both recreational and native subsistence hunters and, although viewing demand has not been determined, they are considered to be an important component of the wilderness scene (A.F.W.D. 1984).

13.2 FOOD

Conifer needles are the most important food on a year-long basis and comprise virtually the entire diet during the period of snow cover, when feeding activity is confined largely or exclusively to conifer trees (Pendergast and Boag 1970; Salt and Salt 1976; Keppie 1977). Lodgepole pine is the major food species in western Alberta (Table 21), although white spruce is seasonally important, and new leaders of this species are actively selected by incubating hens (Pendergast and Boag 1970; McCourt et al. 1973; Herzog 1978). White spruce and larch are major dietary constituents elsewhere, species selection apparently varying at least in part with availability (Zwickel et al. 1974; U.S.F.W.S. 1984d).

Ground vegetation, primarily leaves, flowers and fruit of Vaccinium spp., provides a major part of the diet during the snow-free period (McCourt 1969; Pendergast and Boag 1970; McCourt et al. 1973; Herzog 1978). Arthropods are eaten to some extent by adults and appear to be particularly important to young broods (McCourt 1969; Pendergast and Boag 1970).

Potential food supply for this species is virtually unlimited in conifer-dominated habitats (Pendergast and Boag 1971). Lodgepole pine needles, the major dietary component, feature high gross energy values but their low crude protein content and low digestibility (Boag and Kiceniuk 1968; Pendergast and Boag 1971) probably necessitate a large intake in order to meet nutritional requirements.

13.3 COVER AND TERRAIN

In western Alberta spruce grouse are found primarily in lodgepole pine forest, a fire-induced disclimax (McCourt 1969; McLachlin 1970; Pendergast and Boag 1971; Sharp 1973; Boag et al. 1979, 1984), but also in white spruce and other conifer-dominated forests, in spruce bogs, mixed woods and deciduous woods, and in grasslands, shrublands and subalpine meadows in the vicinity of suitable forest cover (McCourt 1969; McLachlin 1970; Sharp 1973; Stelfox et al. 1973; Wiseley 1979; Holroyd and VanTighem 1983). In the mountains they are found mainly in valley bottom forests (Holroyd and VanTighem 1983) but extend into the subalpine (Sharp 1973; Holroyd and VanTighem 1983).

Studies in the foothills west of Turner Valley have shown that there are sex, age and seasonal differences in occupation of cover types, and of occupation of sites within a cover type. In this area males were found primarily in lodgepole pine forest and secondarily in white spruce forest and older mixed forest, but never in meadow or marsh (McLachlin 1970). Although lodgepole pine forest was the major available cover type only 28% of it was occupied by resident males, suggesting active selection for certain habitat features. This occupied area differed structurally from peripheral areas (used to some extent by wandering yearlings) comprising the remainder of the forest in having greater

Table 21. Food species used by spruce grouse in Alberta.

Reference, Area and Diet Composition[1]	
Species	Pendergast and Boag 1970 (Swan Hills)[2]
Trees and Shrubs	
Betula spp.	0-0.1%s
Cornus canadensis	0-tr.s
Picea spp.	1.4%w,3.8-21.7%s
Pinus contorta	97.5%w,7.7-57.1%s
Rubus chamaemorus	0-0.3%s
Vaccinium membranaceum	0-31.9%s
V. myrtilloides	0-tr.s
V. vitis-idaea	13.1-20.5%s
Graminoids	
Carex spp.	0-2.8%s
Gramineae	tr.s
Forbs	
Streptopus amplexifolius	0-2.2%s
Taraxacum officinale	tr.s
Tiarella trifoliata	0-0.8%s
Horsetails, Club-mosses, Mosses and Fungi	
Equisetum spp.	0-2.5%s
Fungi	0-2.0%s
Musci	0-3.4%s
Arthropoda	0-0.7%s

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[1] w = winter; s = spring-summer-fall.

[2] percent winter diets determined from crop contents (n=22) of birds over 5 months of age collected December-February. Percent spring-summer-fall diets determined from crop contents of birds over 5 months of age collected March-May (n=24), June-August (n=33) and September-November (n=20); percentages refer to range of values over the three periods. All percentages refer to dry weights.

overstory cover (mainly in the 25-50% and 50-75% canopy cover classes), lower middlestory cover (generally <25%), greater stem density (mean 6600 stems/ha) and canopy height (mean 8.2 m), and lower slope of the forest floor (mean 6.6°). Unoccupied areas were generally the upper slopes of the hills where greater exposure, drainage and thinner soil contributed to differences in vegetation cover. Display areas were in more open parts of the home range, where lower overstory cover, lower stem density and an absence of smaller trees facilitated display flights (MacDonald 1968; McLachlin 1970). By contrast moulting males tended to select denser vegetation (McLachlin 1970; Herzog and Boag 1978), as reflected by greater white spruce cover and greater middlestory cover of willow, alder and all species combined (McLachlin 1970).

In the same study area, females used 40% of the available pine forest, but only 5% of the spruce forest and 8% of the poplar forest (McCourt 1969). Like males, they selected areas of greater overstory canopy cover (mainly in the 25-50 and 50-75% classes), lower middlestory cover (generally <25%), greater stem density (mean 4954 stems/ha) and canopy height (mean 8.06 m), and lower slope values (mean 6.95°) than in the forest as a whole. Females with broods tended to occur in parts of the occupied area featuring a relatively light overstory but heavy middlestory, while females without broods were found in areas where both the overstory and middlestory were relatively heavy.

This species nests on the ground, most commonly within 10 cm of the base of a single tree or between closely adjoining trees, but also under willow clumps, juniper mats or horizontal logs (Keppie and Herzog 1978). Nest site selection is poorly understood and, although nest success is positively correlated with extent of concealment, concealment varies widely among different females (Keppie and Herzog 1978; Redmond et al. 1982). Shrub cover may be important in providing concealment against predators; Boag et al. (1984) found that nests were less vulnerable to predation when shrub canopy cover was 10% or more within a 2 m radius of the nest.

13.4 SPACE

Use of space is dependent on sex, age and time of year (McCourt 1969; McLachlin 1970; Herzog and Boag 1978). Spacing behaviour of adults appears to regulate breeding densities, which may as a consequence vary little from year to year (Boag et al. 1979). Over 10 years of study in the foothills density of birds in the spring population varied from 10.5 to 19.3/km^2 (Boag et al. 1979).

Maximum spacing occurs during the breeding season, when adult males occupy uniformly spaced, aggregated territories averaging 1.0 ha (range 0.3-1.9 ha) in suitable blocks of habitat, and females occupy uniformly spaced territories averaging 2.3 ha (0.6-3.9 ha) peripheral to the central aggregate of males (Herzog 1977a; Herzog and Boag 1978). Both male and female yearlings wander widely in early spring (mean home ranges 39.6 ha [10.0-58.4 ha] and 15.4 ha [5.3-37.8 ha]), during which time they presumably learn the locations of adult territories and locate unoccupied habitat (Keppie 1975; Herzog 1977a; Herzog and Boag 1978; Boag et al. 1979). Yearling females then either establish territories similar to those of adults or are forced to emigrate; similarly some yearling males establish territories and some emigrate, although most occupy large areas (mean 8.6 ha, range 2.3-14.8 ha) peripheral to the established males and overlapping several female territories (Herzog and Boag 1978).

The size and shape of female breeding territories appear to be strongly influenced by the availability of food resources (Herzog 1978), particularly mature white spruce trees which are a preferred food source during incubation (Pendergast and Boag 1970; McCourt et al. 1973; Herzog 1978). Nesting usually occurs near the periphery of the territory (Herzog and Boag 1978), averaging 39-123 m away from feeding sites (Herzog 1978). Subsequent to hatching, female home ranges expand and begin to overlap extensively; areas occupied by females with broods average 29.0 ha (20.6-50.1 ha) and those without broods 16.8 ha (7.4-37.7 ha) (Herzog and Boag 1978).

All sex and age groups tend to be rather sedentary in winter, home ranges of adult males averaging 2.1 ha (single sample), adult females 2.0 ha (0.8-3.0 ha), yearling males 6.8 ha (1.9-14.7 ha) and yearling females 3.6 ha (0.6-7.0 ha) (Herzog and Boag 1978). Both adult and yearling females are known to spend up to several days associated with small blocks of habitat or even with single trees during winter (Herzog and Boag 1978).

Local populations may include both resident and migratory birds. Herzog and Keppie (1980) found that 39% of their study population was migratory, moving up to 9.5 km between breeding and wintering sites each year. The remainder of the population was resident in the same general area year-round (Herzog and Boag 1978; Herzog and Keppie 1980).

13.5 SIZE AND INTERSPERSION OF HABITAT UNITS

Minimum size of suitable habitat blocks may be set in part by social factors, such as the tendencies for male territories to be clumped together, for females to consort with males during the breeding season, and for yearling males to occupy territories adjacent to established males (McCourt 1969; McLachlin 1970; Herzog and Boag 1978). Areas of apparently suitable habitat, but smaller than normal home ranges, are not used by resident males (McLachlin 1970). Reoccupation of vacated territories occurs rapidly in large blocks of habitat (McLachlin 1970; Herzog and Boag 1978; Boag et al. 1979), but apparently less rapidly or not at all in smaller areas (McLachlin 1970).

Recent work in the Adirondack Mountains of New York indicates that patterns of occupation and extinction in patchy habitats can be predicted quantitatively on the basis of size and arrangement of habitat units and demographic characteristics of spruce grouse (Fritz 1979). In that area, unoccupied patches were significantly smaller and significantly further from occupied patches than were other occupied sites. Occupied patches ranged from 28 to 591 ha in size (average 157 ha) whereas unoccupied patches were 20-118 ha, and averaged 56 ha in size (Fritz 1979).

Within blocks of suitable habitat, features such as openings in the forest, high hills, streambeds and change in vegetation type may form natural boundaries for resident male home ranges, but not for those of yearlings (McLachlin 1970). Females with broods are known to use open, treeless areas (Sharp 1973) but there are no data on optimum opening sizes.

Spruce grouse are vulnerable to habitat disruption and hunting pressure (Salt and Salt 1976) and disappear with logging of white spruce and lodgepole pine forests in the foothills (Stelfox et al. 1973).

13.6 HABITAT MODELS

A review of habitat requirements of Alaskan spruce grouse, including a habitat suitability index model, is currently available in draft form (U.S.F.W.S. 1984d).

14.0 WHITE-TAILED PTARMIGAN

14.1 GENERAL

The distribution of white-tailed ptarmigan in Alberta is limited to the Rocky Mountains (Salt and Salt 1976). Populations are resident in this biome at elevations from about 1600 to 3075 m (Salt and Salt 1976; Herzog 1980; Salt 1984).

14.2 FOOD

Leaves and fruits of a variety of alpine plants provide the diet of this species. Within the North American range as a whole (Colorado through Alberta and British Columbia to Alaska), common spring and summer foods are willow and buttercup leaves, dryad flowers, grass and sedge seeds and bistort fruits; autumn foods are willow buds, twigs, and leaves, and Draba, bistort, crowberry and Vaccinium fruits; and winter foods are willow, alder and birch buds and twigs, depending on location (Weeden 1967).

Only fragmentary data are available on food habits in Alberta. Weeden (1967) reported white dryad leaves and flowers, willow leaves, and buttercup leaves to be the major constituents in three crops collected in Banff and Waterton Lakes N.P. during May to July and Herzog (1977b) observed females with broods in the Kananaskis area feeding repeatedly on the flowers and leaves of Smelowskia calycina, an alpine Cruciferae. Sedges, heaths, fleabanes and individual willow (Salix nivalis) and buttercup (Ranunculus eschscholtzii) species were reported by Salt (1984) to be the most important food plants in the Sunwapta Pass and Kananaskis regions. A high proportion of the diet of young birds consists of small insects and other invertebrates such as snails (Salt and Salt 1976; Salt 1984). Buds and seeds of willows and other species (e.g., cinquefoil, buffalo-berry, rose) are the primary winter foods (Salt and Salt 1976; Herzog 1980; Holroyd and VanTighem 1983; Salt 1984) but weed seeds and waste grain around human habitations are used during severe winters (Salt and Salt 1976).

Water appears to be an integral part of summer habitat, but whether free water is actually required for drinking is unknown. Chicks can obtain moisture from dew (Salt and Salt 1976).

14.3 COVER AND TERRAIN

White-tailed ptarmigan are found during spring and summer mainly on open rocky slopes and in alpine meadows above treeline (Salt and Salt 1976; Herzog 1977b; Holroyd and VanTighem 1983; Salt 1984), but also in krummholz and fir/alpine larch cover types (Sharp 1973; Salt 1984). Key habitat features apparently are an abundance of rocks suitable for cover (>30 cm diameter) and sufficient moisture for plant growth (Herzog 1977b; Holroyd and VanTighem 1983). Prime feeding sites are located in damp areas such as around small seeps, along pond or stream edges, or at the edges of late snow banks (Salt 1984).

Herzog (1977b) analysed sightings made during July to August in the Kananaskis area and found that rocks comprised nearly 50% of the ground cover in occupied habitats; low willows, mosses, grasses, sedges, saxifrage, groundsel, cinquefoil and everlasting were the major plant species. Large expanses of dry alpine tundra with vegetation cover of heath, heather and mountain avens were not used. Few ptarmigan were located more than 25 m from a snowfield, stream or lake (mean distance 7 m). Willows or conifers were usually in the vicinity of ptarmigan sightings (mean distances 12 and 14 m) but hiding and thermal cover appeared to be provided mainly by rocks.

Nesting occurs on dry ground, concealment being provided by short grasses and willows (Salt and Salt 1976; Salt 1984). Most nests are located on slopes of <12°, with highest nest concentrations on southerly slopes, and typically with 40% or more of the ground cover around the nest site consisting of scree or decayed bedrock (Salt 1984).

Habitat use in winter appears to be dependent largely on snow cover (Herzog 1980; Salt 1984). The irregular topography of prime high elevation range provides both open, windswept areas for feeding and deep snow drifts for thermal cover (Salt 1984). During winters of low snow accumulation, when food (mainly willow) is readily available above snow, ptarmigan may remain in the same alpine cirques as occupied during summer (Herzog 1980; Salt 1984), but otherwise move downward into shrubby areas and open conifer forests (Sharp 1973; Wiseley 1979; Herzog 1980; Holroyd and VanTighem 1983; Salt 1984) and occasionally into the vicinity of valley bottom ranches and settlements (Salt and Salt 1976). Herzog (1980) provides the following structural description of winter habitats:

1. "Alpine cirque (2400 to 2600 m elevation): open tundra with scattered clumps of willow 5 to 30 cm in height.
2. Treeline krummholz (2300 to 2500 m): widely spaced dwarf conifers, primarily alpine fir, Engelmann spruce and whitebark pine, with occasional patches of willow up to 50 cm in height.
3. Subalpine forest (2000 to 2400 m): open forest of spruce, fir and alpine larch, with scattered clumps of willows, dwarf birch and juniper.
4. Stream course (1900 to 2100 m): drainageways through subalpine forest dominated by willows 2 to 3 m in height at lower elevations."

14.4 SPACE

White-tailed ptarmigan have a terrritorial breeding system (Salt 1984) but territory sizes have not been documented for Alberta. In preferred breeding areas nests occasionally are found within 50 m of each other but may be 500-1200 m apart even in good habitat (Salt 1984).

Seasonal movements are erratic and difficult to categorize (Salt 1984). Breeding occurs only at middle elevations but males and broodless females disperse and may move to higher elevation basins by midsummer (Herzog 1977b; Salt 1984). Females with broods remain on the breeding range, as described under spring and summer habitat above (Sharp 1973; Herzog 1977b; Holroyd and VanTighem 1983; Salt 1984), or move downslope along stream courses, even penetrating below treeline (Herzog 1977b; Salt 1984). A downward shift involving all sex and age classes generally occurs by late winter, although some individuals remain on the breeding range and there are some winter records (primarily of males) on high elevation rock peaks (Salt 1984). Downslope movements of 2.5 to 7.5 km have been documented during winter, the extent of movement apparently being related to food availability as influenced by snow cover (Herzog 1980). There is some evidence that males remain closer to the summer range in winter than do females, but whether this is related to territorial, nutritional or other considerations is unknown (Herzog 1980).

14.5 SIZE AND INTERSPERSION OF HABITAT UNITS

Minimum area requirements of white-tailed ptarmigan have not been documented. In Alberta, small alpine basins with rock slides and rocky stream courses, and adjacent shrublands and subalpine forest for alternate winter food and cover, provide the year-round habitat requirements (Herzog 1977b, 1980; Salt 1984).

14.6 HABITAT MODELS

No formal models describing habitat use by this species were found.

15.0 SHARP-TAILED GROUSE

15.1 GENERAL

Sharp-tailed grouse are found throughout the province, with the exception of the Rocky Mountains where they occur only as a rare vagrant (Salt and Salt 1976). They are most abundant in the Aspen Parkland and parts of the prairie biome (including the Peace River area) but extend into the foothills and throughout the boreal forest in suitable habitat (Salt and Salt 1976; A.F.W.D. 1984). The species is a major game bird and sustains some recreational viewing on the spring courtship/dancing grounds (A.F.W.D. 1984).

15.2 FOOD

The diet of juveniles and adults consists primarily of the seeds, fruits, buds and leaves of a wide variety of plant species and a negligible percentage of insects; newly hatched chicks subsist entirely on insects but gradually change to a plant diet by late summer (Pepper 1972; Schmidt 1980). Agricultural crops (e.g., wheat, oats, rye, barley, buckwheat) provide an important food source where available, as do berries of native shrubs such as juniper, silverberry, snowberry and rose (Pepper 1972; Salt and Salt 1976; Schmidt 1980). Other foods reported to be used in western Canada include fruits of bearberry, choke cherry, saskatoon and gooseberry, catkins and buds of aspen and river birch, buds of choke cherry, saskatoon, balsam poplar, pin cherry, buffalo-berry, willow and silverberry, and flowers and leaves of dandelion, perennial sowthistle, prairie crocus and grasses (Schmidt 1980).

15.3 COVER AND TERRAIN

Sharp-tailed grouse occupy a variety of habitats including croplands, grasslands, parkland and early successional stages of mixedwoods and boreal forest (Aldrich 1963; Pepper 1972). Patterns of habitat use vary with cover type availability, but key features of habitat appear to be grassland or cropland areas for foraging and closely interspersed shrubland/woodland areas for escape and resting cover (Pepper 1972; Salt and Salt 1976; Moyles 1981). In uncultivated aspen parkland in east-central Alberta all available habitats (grassland, grassland-low shrub transition, low shrub, low shrub-tall shrub transition, tall shrub, aspen woodland) sustained some use throughout the year, with the exception of sedge marsh which was used only during winter (Moyles 1981). Over 70% of annual use was in grassland and in grassland-low shrub transition, the major seasonal change being increased use of treed habitat during winter and spring. By contrast, in an agricultural area in western Saskatchewan cultivated fields were the major habitat used during the autumn-spring period (Schmidt 1980). Other seasonally important habitats were grassland (spring and autumn), gravel roads (winter) and tall shrubs/trees (autumn, winter and spring).

Sharp-tailed grouse nest on the ground, requiring dense cover 25 cm or more in height for concealment (Pepper 1972; Caldwell 1976; Salt and Salt 1976; review by Nietfeld et al. 1984). Preferred nesting sites are ungrazed or lightly grazed native grassland and low shrubland, although cultivated areas (tame hay fields, cultivated stubble) may be used with reduced success (Pepper 1972; Caldwell 1976). Nesting rarely occurs in treed areas, but in parkland habitat nests usually are located within 14 m of aspen forest or dense aspen regrowth (Pepper 1972; Nietfeld et al. 1984).

15.4 SPACE

Communal male dancing grounds or arenas, located primarily on dry, elevated, open sites, provide a focal point for sharp-tailed grouse activities (Evans 1969; Rippin

1970; Rippin and Boag 1974; Pepper 1972; Caldwell 1976; Moyles 1977). Subdivision of these arenas into small, contiguous territories provides space for courtship and copulation during a short period in spring, but most males establish territories during autumn and winter and remain in the vicinity over most of the year (Rippin 1970; Pepper 1972; Rippin and Boag 1974; Moyles 1977). Once established individual males return to the same arenas year after year (Evans 1969; Caldwell 1976). However, young males may move considerable distances in fall in attempts to establish themselves on arena territories (Caldwell 1976; Moyles 1977).

Although females do not participate in communal displays all breeding takes place on the arenas (Caldwell 1976; Salt and Salt 1976). Nests are located within 1.6 km (usually within 800 m) of the nearest arena (Pepper 1972; Caldwell 1976).

Large flocks formed subsequent to brood breakup may move about within several square miles during fall and winter (Caldwell 1976; Salt and Salt 1976).

15.5 SIZE AND INTERSPERSION OF HABITAT UNITS

A mosaic of plant communities, predominantly native grassland and low shrub but including deciduous woodland and extensive ecotones, provides optimal habitat for sharp-tailed grouse (Pepper 1972; Moyles 1981). Carrying capacity appears to be limited primarily by the availability of suitable habitat in proximity to arena sites. In Saskatchewan, summer observations of sharp-tailed grouse were positively correlated with the amount of ungrazed native grass-shrub and tame haylands within 1.6 km of arenas (Pepper 1972). In aspen parkland in Manitoba, the largest dancing grounds were all located in areas of light or no grazing with grassland comprising 69% or more of a 1.4 km^2 area around the arena site; arenas ceased to be used when grassland coverage within 0.8 km fell below 58% (Caldwell 1976). Similarly, in aspen parkland in Alberta the number of displaying males on arenas was inversely related to total aspen cover within 0.8 km (Moyles 1981). The latter observation suggests that although clumps of aspen are used for resting and escape cover, and thus are an important habitat component, expansion of the aspen community at the expense of grassland eventually reduces the suitability of an area for this species.

Fire is an important factor in creating and maintaining sharp-tailed grouse habitat, especially in reducing tall or dense cover on arenas (Sexton and Gillespie 1979). In Boreal Forest areas, agricultural clearing and other disturbances may provide suitable habitat, but this benefit is transitory if cleared land is brought into full agricultural production (A.F.W.D. 1984). Similarly, in parkland and prairie regions intensive grazing and clean-farming practices reduce habitat suitability and thus sharp-tailed grouse populations (Pepper 1972; A.F.W.D. 1984).

15.6 HABITAT MODELS

Sharp-tailed grouse habitat requirements are reviewed in detail by Nietfeld et al. (1984), drawing on literature from throughout the North American range of the species. Based on this review, IEC Beak (1984h) provide a quantitative model for assessing habitat suitability for sharp-tailed grouse in each of 278 habitat subregions in Alberta.

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17.0 APPENDIX 1: LIST OF COMMON AND SCIENTIFIC NAMES USED IN THE TEXT

17.1 COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES

(Common names are as used in the original citations; scientific names follow Moss, E.H. 1983. Flora of Alberta (2nd ed.). University of Toronto Press. 687 pp.).

Common Name	Scientific Name
alder	*Alnus* sp.
alpine larch	*Larix lyallii*
arnica	*Arnica* sp.
arrowhead	*Sagittaria* sp.
aspen	*Populus tremuloides*
balsam poplar	*Populus balsamifera*
balsam-root	*Balsamorhiza sagittata*
beaked hazelnut	*Corylus cornuta*
bearberry	*Arctostaphylos* sp.
birch	*Betula* sp.
bistort	*Polygonum* sp.
black elder	*Sambucus melanocarpa*
black spruce	*Picea mariana*
bog bilberry	*Vaccinium uliginosum*
bog cranberry	*Vaccinium vitis-idaea*
bracted honeysuckle	*Lonicera involucrata*
brome	*Bromus* sp.
buffalo-berry	*Shepherdia* sp.
bulrush	*Scirpus* sp.
buttercup	*Ranunculus* sp.
cattail	*Typha* sp.
choke cherry	*Prunus virginiana*
cinquefoil	*Potentilla* sp.
clasping-leaf pondweed	*Potamogeton richardsonii*
common cattail	*Typha latifolia*
common great bulrush	*Scirpus validus*
crowberry	*Empetrum nigrum*
dandelion	*Taraxacum* sp.
dogwood	*Cornus stolonifera*
Douglas fir	*Pseudotsuga menziesii*
dryad	*Dryas* sp.
duckweed	*Lemna* sp.
dwarf birch	*Betula glandulosa*
Engelmann spruce	*Picea engelmannii*
everlasting	*Antennaria* sp.
fescue	*Festuca* sp.
fir	*Abies* sp.
fireweed	*Epilobium angustifolium*
fleabane	*Erigeron* sp.

Common Name	Scientific Name
giant bur-reed	*Sparganium eurycarpum*
gooseberry	*Ribes* sp.
great bulrush	*Scirpus acutus*
green alder	*Alnus crispa*
groundsel	*Senecio* sp.
hairy wild rye	*Elymus innovatus*
hazel	*Corylus cornuta*
heath	*Phyllodoce glanduliflora*
heather	*Cassiope tetragona*
high-bush cranberry	*Viburnum trilobum*
horsetail	*Equisetum* sp.
jack pine	*Pinus banksiana*
june grass	*Koelaria cristata*
juniper	*Juniperus* sp.
Labrador tea	*Ledum* sp.
larch	*Larix* sp.
lodgepole pine	*Pinus contorta*
low-bush cranberry	*Viburnum edule*
mountain avens	*Dryas* sp.
paper birch	*Betula papyrifera*
perennial sowthistle	*Sonchus uliginosus*
pin cherry	*Prunus pensylvanica*
pine	*Pinus* sp.
pondweed	*Potamogeton* sp.
poplar	*Populus* sp.
prairie crocus	*Anemone patens*
prickly rose	*Rosa acicularis*
raspberry	*Rubus* sp.
reed grass	*Calamagrostis* sp.
rhododendron	*Rhododendron* sp.
river birch	*Betula occidentalis*
rose	*Rosa* sp.
rough fescue	*Festuca scabrella*
saskatoon	*Amelanchier alnifolia*
saxifrage	*Saxifraga* sp.
sedge	*Carex* sp.
shrubby cinquefoil	*Potentilla fruticosa*
silver-berry	*Elaeagnus commutata*
snowberry	*Symphoricarpos albus*
spike rush	*Eleocharis* sp.
spruce	*Picea* sp.
subalpine fir	*Abies lasiocarpa*
subalpine larch	*Larix lyallii*
sweet flag	*Acorus calamus*
tamarack	*Larix laricina*
tufted hairgrass	*Deschampsia caespitosa*
twining honeysuckle	*Lonicera dioica*
water milfoil	*Myriophyllum* sp.
wheatgrass	*Agropyron* sp.

Common Name	Scientific Name
white dryad	*Dryas hookeriana*
white spiraea	*Spiraea lucida*
white spruce	*Picea glauca*
white-bark pine	*Pinus albicaulis*
willow	*Salix* sp.
yellow pond-lily	*Nuphar variegatum*

17.2 LIST OF COMMON AND SCIENTIFIC NAMES OF MAMMALS.

(Nomenclature follows Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press. 438 pp.).

Common Name	Scientific Name
Arctic shrew	*Sorex arcticus*
badger	*Taxidea taxus*
beaver	*Castor canadensis*
bighorn sheep	*Ovis canadensis*
black bear	*Ursus americanus*
bobcat	*Lynx rufus*
bushy-tailed wood rat	*Neotoma cinerea*
caribou	*Rangifer tarandus*
chestnut-cheeked vole	*Microtus xanthognathus*
Columbian ground squirrel	*Spermophilus columbianus*
coyote	*Canis latrans*
deer mouse	*Peromyscus maniculatus*
dusky shrew	*Sorex obscurus*
elk	*Cervus elaphus*
ermine	*Mustela erminea*
fisher	*Martes pennanti*
Franklin's ground squirrel	*Spermophilus franklinii*
golden-mantled ground squirrel	*Spermophilus lateralis*
grizzly bear	*Ursus arctos*
heather vole	*Phenacomys intermedius*
hoary marmot	*Marmota caligata*
least chipmunk	*Eutamius minimus*
least weasel	*Mustela nivalis*
long-tailed vole	*Microtus longicaudus*
long-tailed weasel	*Mustela frenata*
lynx	*Lynx lynx*
marten	*Martes americana*
masked shrew	*Sorex cinereus*
meadow jumping mouse	*Zapus hudsonius*
meadow vole	*Microtus pennsylvanicus*
mink	*Mustela vison*
moose	*Alces alces*
mountain goat	*Oreamnos americanus*
mountain lion	*Felis concolor*
mule deer	*Odocoileus hemionus*
muskrat	*Ondatra zibethicus*
northern bog lemming	*Synaptomys borealis*
northern flying squirrel	*Glaucomys sabrinus*
northern pocket gopher	*Thomomys talpoides*
pigmy shrew	*Microsorex hoyi*
pika	*Ochotona princeps*
porcupine	*Erithizon dorsatum*
prairie vole	*Microtus ochrogaster*
raccoon	*Procyon lotor*

Common Name	Scientific Name
red fox	*Vulpes vulpes*
red squirrel	*Tamiasciurus hudsonicus*
red-backed vole	*Clethrionomys gapperi*
Richardson's ground squirrel	*Spermophilus richardsonii*
Richardson's water vole	*Arvicola richardsoni*
river otter	*Lutra canadensis*
striped skunk	*Mephitis mephitis*
snowshoe hare	*Lepus americanus*
thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
water shrew	*Sorex palustris*
western jumping mouse	*Zapus princeps*
white-tailed jackrabbit	*Lepus townsendii*
white-tailed deer	*Odocoileus virginianus*
wolf	*Canis lupus*
wolverine	*Gulo gulo*
woodchuck	*Marmota monax*
yellow pine chipmunk	*Eutamias amoenas*

17.3 LIST OF COMMON AND SCIENTIFIC NAMES OF BIRDS.

(Nomenclature follows Salt, W.R. and J.R. Salt. 1976. The Birds of Alberta. Hurtig Publishers, Edmonton. 498 pp.).

Common Name	Scientific Name
American avocet	*Recurvirostra americana*
American bittern	*Botaurus lentiginosus*
American coot	*Fulica americana*
American kestrel	*Falco sparverius*
American wigeon	*Anas americana*
bald eagle	*Halieetus leucocephalus*
barred owl	*Strix varia*
Barrow's goldeneye	*Bucephala islandica*
belted kingfisher	*Megaceryle alcyon*
black tern	*Chlidonias niger*
black-crowned night heron	*Nycticorax nycticorax*
blue grouse	*Dendragapus obscurus*
blue-winged teal	*Anas discors*
broad-winged hawk	*Buteo platypterus*
Bonaparte's gull	*Larus philadelphia*
boreal owl	*Aegolius funereus*
bufflehead	*Bucephala albeola*
California gull	*Larus californicus*
Canada goose	*Branta canadensis*
canvasback	*Aythya valisineria*
common goldeneye	*Bucephala clangula*
common loon	*Gavia immer*
common merganser	*Mergus merganser*
common snipe	*Capella gallinago*
common tern	*Sterna hirundo*
Cooper's hawk	*Accipiter cooperii*
double-crested cormorant	*Phalacrocorax auritus*
eared grebe	*Podiceps nigricollis*
Forster's tern	*Sterna forsteri*
Franklin's gull	*Larus pipixcan*
gadwall	*Anas strepera*
golden eagle	*Aquila chrysaetos*
goshawk	*Accipiter gentilis*
gray partridge	*Perdix perdix*
great blue heron	*Ardea herodias*
great gray owl	*Strix nebulosa*
great horned owl	*Bubo virginianus*
greater yellowlegs	*Tringa melanoleuca*
green-winged teal	*Anas crecca*
harlequin duck	*Histrionicus histrionicus*
hawk owl	*Surnia ulula*
herring gull	*Larus argentatus*
hooded merganser	*Lophodytes cucullatus*

Common Name	Scientific Name
horned grebe	*Podiceps auritus*
killdeer	*Charadrius vociferus*
lesser scaup	*Aythya affinis*
lesser yellowlegs	*Tringa flavipes*
long-eared owl	*Asio otus*
mallard	*Anas platyrhynchos*
marbled godwit	*Limosa fedoa*
marsh hawk	*Circus cyaneus*
merlin	*Falco columbarius*
northern shoveler	*Anas clypeata*
osprey	*Pandion haliaetus*
pied-billed grebe	*Podilymbus podiceps*
pintail	*Anas acuta*
piping plover	*Charadrius melodus*
pygmy owl	*Glaucidium gnoma*
redhead	*Aythya americana*
red-necked grebe	*Podiceps grisegena*
red-tailed hawk	*Buteo jamaicensis*
ring-billed gull	*Larus delawarensis*
ring-necked duck	*Aythya collaris*
ring-necked pheasant	*Phasianus colchicus*
ruddy duck	*Oxyura jamaicensis*
ruffed grouse	*Bonasa umbellus*
sandhill crane	*Grus canadensis*
saw-whet owl	*Aegolius acadicus*
sharp-shinned hawk	*Accipiter striatus*
sharp-tailed grouse	*Pediocetes phasianellus*
short-billed dowitcher	*Limnodromus griseus*
short-eared owl	*Asio flammeus*
solitary sandpiper	*Tringa solitaria*
spotted sandpiper	*Actitis macularia*
spruce grouse	*Canachites canadensis*
sora	*Porzana carolina*
surf scoter	*Melanitta perspicillata*
Swainson's hawk	*Buteo swainsoni*
upland sandpiper	*Bartramia longicauda*
Virginia rail	*Rallus limicola*
western grebe	*Aechmophorus occidentalis*
white pelican	*Pelecanus erythrorhynchos*
white-tailed ptarmigan	*Lagopus leucurus*
white-winged scoter	*Melanitta deglandi*
willet	*Catoptrophorus semipalmatus*
Wilson's phalarope	*Steganopus tricolor*
yellow rail	*Coturnicops noveboracensis*